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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See page 93, July 19. 6455

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See Advertisement page 83, July 19.

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See Advertisement page 28. 6462

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See Advertisement page 47, July 5. 2402

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See Illus. Advt. last week, page 15. 6211

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COMMENCING 23rd SEPTEMBER, 1918.

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M 93

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Tenders before 11 a.m. on Friday, the 2nd August, 1918, addressed to THE SECRETARY, H.M. Office of Works, &c., Storey's Gate, London, S.W. 1, for the SUPPLY of CONDUITS, TUBES and FITTINGS.

Forms of Tender, &c., may be obtained on application to THE CONTROLLER OF SUPPLIES, H.M. Office of Works, &c., King Charles Street, Westminster, London, S.W. 1. M 209

BOROUGH OF SANDWICH.

TO ENGINEERS AND OTHERS.

The Corporation of Sandwich invite

Tenders for the Purchase of their STEAM PUMPING PLANT at their Waterworks, Woodnesborough, Sandwich, consisting of Well Pumps, Engines and Boilers complete. Particulars of the plant and Conditions of Sale may be obtained from the BOROUGH SURVEYOR, Sandwich, to whom Tenders should be delivered on or before 3rd August next. The above plant can be seen at work by intending purchasers at any time during the day, upon application being made to the Borough Surveyor.

The Corporation reserve to themselves the right to accept Tenders for the whole or part of the above machinery, and do not bind themselves to accept the highest or any Tender.

R. SAUNDERS,
Borough Surveyor.

Borough Surveyor's Office,
Sandwich, 22nd July, 1918. M 210

APPOINTMENTS OPEN.

MANCHESTER EDUCATION COMMITTEE.

NEWTON HEATH JUNIOR TECHNICAL SCHOOL.

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The Committee invite

Applications for the Post of ASSISTANT MASTER at the above School, with qualifications in Machine Drawing with Geometry, Applied Mechanics and Heat Engines. Candidates should have had teaching experience and have served in Works and Drawing Office.

The successful Candidate will be allowed to teach on two evenings per week (Applied Mechanics).

Applications should be made on a form obtainable at these Offices, and should be returned to me by July 31st.

SPURLEY HEY,
Director of Education.

Education Offices,
Deansgate, Manchester.
July, 1918. M 138

COUNTY BOROUGH OF DARLINGTON.

TECHNICAL COLLEGE.

Engineering Lecturer REQUIRED to teach Elementary Stages of Engineering Science, Machine Drawing and Geometry. Workshop experience essential. Salary required to be stated. Forms of Application from the undersigned to be returned completed on or before 12th August.

A. C. BOYDE,
Secretary.

Education Office,
Darlington.
July, 1918. M 348

NORTHERN COMMAND.

ESTABLISHMENT FOR ENGINEER SERVICES.

Hydraulic Superintendent REQUIRED to take charge of Dock Hydraulic Installation in Norfolk.

Applicants must be thoroughly trained practical Mechanical Engineers, with experience in the supervision and operation of slow speed steam-driven hydraulic pumping engines, Lancashire boilers and accumulators, also in the maintenance of high pressure mains, hydraulic cranes and general deck plant.

Experience in the operation and maintenance of hydraulic packing presses and intensifiers will be advantageous.

Salary £4-£5 per week according to experience and ability.

Applications from ineligible or low category men, stating age, qualifications and experience, and accompanied by copies of recent testimonials, should be forwarded as soon as possible, marked "Hydraulic Superintendent" on envelope and addressed:—

CHIEF ENGINEER,
Headquarters, M 237
Northern Command,
York.

Wanted Immediately, by Engineering firm in Yorkshire engaged on urgent War work, a well-educated ENGINEER, age about 30, experienced in conveying, elevating, and general handling machinery. Must have commercial, technical, and workshop experience; knowledge of electric crane design an advantage. No one already on Government work or residing more than 10 miles away need apply.—Apply, stating full particulars, reference, salary, &c., to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and M 221.

Works Engineer Wanted for factory employing 2000 hands, with experience on electrical motor drives, erection and maintenance of medium size machinery and general care of factory buildings. State experience, age, and salary required. No one already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting No. A 5759. M 222

First-class Works Manager REQUIRED to take entire control of Shell Factory Contract; 7000 shells per week. A practical, capable organizer. Only those men who have had a thorough successful career, which will be carefully investigated, need apply. No one already on Government work will be engaged.—Address, M 228, Offices of ENGINEERING.

Wanted, as Soon as Possible, ENGINEERING CLERK OF WORKS to supervise erection of boiler house and steam turbine plant. Knowledge of electrical plant not essential, but sound mechanical experience and ability to read drawings and make working sketches necessary. Salary, including all bonuses, &c., to date, at the rate of £300 per annum. Engagement, subject to satisfactory service, will be for not less than nine months.—Apply in own handwriting, enclosing copies of testimonials and stating how soon duties can be commenced, to GENERAL MANAGER, Electricity Offices, Dunning Street, Sunderland. M 191

Despatch Clerks (Male or Female), REQUIRED for Blue Print Department in an Aeroplane Factory in N.W. London. No one on Government service or residing more than 10 miles away need apply.—Write stating experience and salary required to M 246, Offices of ENGINEERING.

Works Manager Required, thoroughly practical and up-to-date in all modern practice and small mechanism and press work. Able to take entire charge of factory of 3000 hands. Only first-rate men need apply. Liberal salary. Address, M 175, Offices of ENGINEERING.

Buyer Required for a Large up-to-date Factory, 2000 hands. General Engineering. Men with only first class experience need apply.—Address, M 176, Offices of ENGINEERING.

Production Manager Wanted, thoroughly up-to-date in all modern progress systems, for large factory of 3300 hands. Applications from well experienced men only entertained.—Address, M 177, Offices of ENGINEERING.

Chemist, Steelmaking, WANTED. Stock Converter plant and Heroult furnace. No person already on Government work will be engaged.—Apply, giving age, experience, salary required and references, to your nearest EMPLOYMENT EXCHANGE, quoting this Journal and No. A 5227. M 204

Assistant Metallurgical CHEMIST WANTED for an Engineering Works near London. Capable of making analyses of Alloy Steel. No one at present on Government work will be engaged.—Address, stating full particulars and salary expected, to your nearest EMPLOYMENT EXCHANGE mentioning this Journal and M 197.

Assistant Chemist Required, experienced in Brass and General Metallurgical Analysis. State experience, age and salary required.—THE GRAMOPHONE CO., LTD., Hayes, Middlesex. M 143

Large Commercial Firm Requires immediately, Qualified FIELD SURVEYORS with experience of Bush work for the Tropics. Applicants must be ineligible for Military Service and not over 45 years of age, or engaged on Controlled work.—Write, stating age, qualifications, and salary required, to BOX O 536, LEE & NIGHTINGALE, Liverpool. M 128

Works Manager Wanted by large and old established General Engineering Firm in North of England.

Must be experienced in up-to-date methods of production, and have good organizing abilities with actual experience in dilution of labour.

No one on Government work will be engaged.

Address, giving full particulars of experience, age, and salary expected, M 64, Offices of ENGINEERING.

Rate Fixer.—First-class Tool- room Rate Fixer REQUIRED, by a firm in the Midlands engaged on Aero Engine production. Applicants must have had a tool room experience of high-class work. No person already engaged on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5503. L 803

Wanted, Designer for Reinforced Concrete Ships. Good knowledge of Ferro-concrete design essential. No person at present engaged on Government work need apply.—Apply, giving full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and M 124.

Wanted, in a London Technical College, a practical ENGINEER (college trained), to assist in the teaching, day and evening work; one with teaching experience preferred. Temporary engagement.—Address, C.E., 5, St. George's Terrace, Regent's Park, N.W., giving full particulars of training and experience (stating salary), with copies of three testimonials. M 103

Engineer, accustomed to the erection and maintenance of ropeways and conveyor plant; must also have had a general all-round engineering training. No one already employed on Government work will be engaged.—Apply, stating full qualifications, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and M 156.

Wanted, Several Experienced DESIGNING DRAUGHTSMEN having sound engineering and preferably marine and electrical experience for Government experimental work on the Clyde. No one already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE mentioning this Journal and M 202.

Draughtsman Wanted, for Blast Furnaces and Steel Works on North-East Coast.—Apply your nearest EMPLOYMENT EXCHANGE, stating age, experience and salary required, mentioning this Journal and No. A 5662. Men already engaged on Government work need not apply. M 18

A Large Aircraft Factory in N.W. London REQUIRE several DRAUGHTSMEN with first-class experience. Exceptional opportunities offered to suitable men. No one engaged on Government work or living more than 10 miles away need write to BOX 650, SELLS Ltd., 168, Fleet Street, E.C. 4. M 190

Draughtsmen Required for Aircraft Factory, N.W. District. Aero Engine or Motor Car experience essential. Write fully, stating age, qualifications, experience, and salary required, to BOX T, care of W. H. SMITH & SON, 55, Fetter Lane, E.C. 4. No one at present engaged on Government work or living more than 10 miles away will be engaged. M 189

Electrical Draughtsman WANTED, one with experience in Controllers, Resistances and Switch Gear. No one already engaged on Government work will be employed.—State age, experience and wages required to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and M 194.

ADMIRALTY.

DEPARTMENT OF ELECTRICAL ENGINEERING.

Electrical Draughtsmen REQUIRED, with experience either in Machine and Control Gear Design or general Ship Electrical Installations.

Apply, giving details of experience, stating age, salary required and whether at liberty to accept Admiralty appointment, and forwarding copies of recent testimonials to DIRECTOR OF ELECTRICAL ENGINEERING, ADMIRALTY, Great George Street, London, S.W. 1. M 236

Required for London Aeroplane Factory, N.W. District, DRAUGHTSMAN to assist in checking of tool drawings. Must be accurate and reliable. Also two or three Junior Draughtsman for jigs, tools, etc. No one engaged on Government work or living more than 10 miles away need write to BOX 603, SELLS LTD., 168, Fleet Street, E.C. 4. M 270

Wanted, Several Skilled MECHANICAL DRAUGHTSMEN, for Government Department in London. Gearing and internal combustion engine experience preferred. — Apply personally or by letter to "OFFERS OF SERVICE" SECTION, Ministry of Munitions, Whitehall Place, S.W. 1. No one on Government work or resident more than 10 miles away will be engaged. M 205

Engineer Draughtsman, Accustomed to Oil Mill design, WANTED for new oil mill.—Write, stating fully and clearly, experience, age, military classification, salary required, and enclose copies of references, to L. E., care of STREETS, 30, Cornhill, E.C. 3. M 226

Draughtsman Required, for a large Iron and Steelworks. Must be a capable man with good experience. No person already on Government work will be engaged.—Apply, stating age, experience and salary, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5711. M 96

First-class Draughtsmen REQUIRED (also one Junior Draughtsman), with experience of Diesel or Semi-Diesel Marine Engines, and their accessories. No one on Government work will be engaged. State age, experience, and salary required.—Apply your nearest EMPLOYMENT EXCHANGE, quoting No. A 5687. M 76

Mechanical Engineering and Maintenance DRAUGHTSMAN WANTED, with ability to take out stresses and strains, for large engineering works in Manchester district. No one already on Government work will be considered.—Apply, with particulars of age, experience, and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5650. M 34

Wanted, Experienced and capable Jig and Tool DRAUGHTSMAN, preferably with experience of Motor Vehicle Manufacture. London district. No person already on Government work will be engaged.—Apply, stating age, salary and full particulars of experience, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 3929. L 802

Draughtsman Required, accustomed to the Design of Centrifugal Pumps, and preferably with knowledge of Electrical Machinery. Good progressive situation for the right man. No one engaged on Government work or residing more than 10 miles away need apply.—State age, training and experience, and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 443.

Draughtsmen.—A Controlled Establishment in the West Riding of Yorkshire, engaged on important high priority work, REQUIRE the SERVICES of a competent MAN, with first-class experience in General Engineering work; also experienced MAN for medium size machine tool work. No person already on Government work will be engaged.—Apply, stating full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning A 4965. L 646

A Lady Tracer is also REQUIRED. The above positions are permanent to reliable individuals. No person already on Government work will be engaged.—Apply, stating full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning A 4965. L 646

Two Experienced Mechanical DRAUGHTSMEN, good permanent prospects, preference to applicants with knowledge internal combustion engines.—Apply, stating age, salary required, and particulars to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 998. No person already employed on Government work will be engaged.

Designing Engineer for Electrical Machines wanted by large firm in Midlands. Must be thoroughly experienced mechanical man with good shop experience. No person already on Government Work will be engaged. Apply, stating experience, age, and salary required to your nearest Employment Exchange mentioning this paper and No. A 5684. M 78

Draughtsman Required to TAKE CHARGE of Coal Washery Department. Experienced men only need apply.—Full particulars in the first place to K 624, Offices of ENGINEERING.

Draughtsmen Wanted, for Engineering Works Plant and Equipment. Only men with good practical shop experience and sound theoretical training need apply. No person already on Government work will be engaged.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this paper and No. A 5636. M 23

Senior Draughtsman Required for a large works. Must have had first-class experience in design of iron and steelworks plant. Good salary paid to suitable man. No person already on Government work will be engaged.—Apply, stating age, experience, and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5710. M 97

Draughtsmen, Mechanical.— Several DRAUGHTSMEN are REQUIRED by a large aeroplane establishment in S.W. London. Applicants should be first-class men, preferably with some shop experience. No one already employed on Government work, or resident more than 10 miles away, will be engaged.—Address, M 102, Offices of ENGINEERING.

Good Mechanical Draughts- MEN WANTED by large Controlled firm in Manchester district. Must be quick and accurate at detail work. No person already on Government work will be engaged.—Apply, with full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5651. M 34

Draughtsman Wanted by first class Company in the Midlands, for heating and ventilating. No one already employed on Government work will be engaged.—Apply, with full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and M 206.

Wanted, for an Old-established aircraft factory on the South Coast, a competent DRAUGHTSMAN to assist chief draughtsman with a view to taking control. A permanent position with good prospects is offered to a thoroughly sound technical man. No person already engaged on Government work will be engaged.—Apply to nearest EMPLOYMENT EXCHANGE, mentioning No. A 5727. M 142

Draughtsman Wanted for controlled firm of constructional engineers in Birmingham area.—State age, salary required and full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning this paper and M 162. No one on Government work will be engaged. M 169

THE SALT TRADE OF THE UNITED STATES.

ONE of the objects contemplated in the foundation of the United States Bureau of Mines was to disseminate information concerning the mining industries, and, in fulfilment of this purpose, the Bureau has recently published a report*, by Mr. W. C. Phalen, on the "Technology of Salt Production in the Union." This report, though taking a wide survey, will be incorporated into a still fuller digest intended to embrace the geology of salt deposits, the theories connected with their origin and formation, the chemistry of the salt beds and natural brines, and, finally, the statistics of salt production in the United States. Two circumstances have led to the early issue of this section; one, the anxiety of the world to find sources of potash to replace the loss of the Stassfurt output during the war; the other, the necessity for examining the economic conditions under which the trade is being prosecuted. Apart from these practical ends, the literature connected with salt manufacture is in a backward state, and the world needs to be informed of the recent developments, mechanical and economical, that the industry has undergone. The internal condition of the trade and the direction its possible expansion could most profitably take, are not sufficiently known to those engaged in it, and the consequences of ill-considered extension in the past are not properly appreciated. The materials for salt production in the United States are wide-spread, can generally be easily handled, and permit a large output, exceeding, in 1915, 5,000,000 tons, having a value of about $12,000,000. These figures seem large, but plant capacity is admitted to be in excess of domestic requirements, and the small value of the commodity hinders distant transportation. This unhealthy condition not only makes competition keen, but prices unremunerative, and trade in many localities is carried on at a loss. The overproduction is estimated at 20 per cent. to 50 per cent., and large up-to-date plants find themselves compelled to work at half their production capacity, while others are temporarily or permanently closed awaiting a better market.

The wear and tear of plant incident to the operation of all salt making is unusually heavy, but to close a factory for only a short time spells ruin. The strong inducement to run the machinery in face of a loss, aggravates the evils of over-production, and it is difficult to find a remedy. But, fortunately, the outcry is not new. Thirty years ago, Chatard, in his review of a similar situation in the salt trade, wrote: "The present plants are able to furnish a supply much larger than can find a fairly profitable market." At that time, the outlook was less hopeful, as there was no prospect of utilising the residual bittern, or mother liquor, for the recovery of potash, bromine, and other chemicals. The price now obtained for some of the bye-products, as magnesium salts, is satisfactory, but inasmuch as prizes are offered for the discovery of a process that will lead to a new or increased use of bromine, we must suppose that the market is over-stocked with this article.

Salt is widely distributed throughout the States; in many parts of the West where the climate is arid, it lies on the ground, a frequent cause of infertility, and, in the Eastern States, enormous stores lie buried, protected from the solvent action of rain by a thick mantle of impervious beds. Its manufacture or collection will, therefore, be widely distributed among local centres, generally determined by the density of population, for, with a commodity whose raw material brine, has no other value than that given it by the cost of sinking the well and pumping, the charges for handling and transportation will limit the area over which the product can be economically distributed. Michigan, supplying the dense population round the Great Lakes, and assisted by cheap fuel drawn from the refuse of the saw mills, has hitherto produced the greatest quantity of salt, but New York State, though a late competitor, is advancing towards the most prominent position. The existence of rock salt was not known in New York till 1878, when, in boring a petroleum well, the mineral was encountered at a depth of 1,280 ft. The value of the discovery was not appreciated till some years later, but about 1895 many wells were being sunk to provide a cheap supply of brine for working soda-ash plant on a large scale. Neighbouring lakes provided a supply of water, that could be brought to the wells by gravity, making the quantity of brine unlimited. The salt bed is known to be of immense extent, not less than 1,100 sq. miles, but undetermined in some directions owing to the thickness of the cover. It extends into Pennsylvania, where it supports a salt industry of local importance, and probably into Ohio, where beds are known to have an aggregate thickness of 148 ft. In this latter State, a natural brine is encountered that is worked for bromine and calcium chloride, as well as salt. The wells are usually sunk to a depth of more than 1,000 ft., the brines of greatest density sinking to the lowest level. But apart from this fact, the reservoirs are growing lower with continual pumping, and the supply is being renewed from the rocks at a higher level. There is, however, enough salt in Ohio to last an indefinite time at the present rate of consumption.

Salt occurs in many other States, as Virginia, Kansas, Louisiana and Texas, the quantities are locally important, but do not differ in any essential particular from the examples quoted. In Utah, however, we meet with a new feature: all the salt being made along the shore of the Great Salt Lake through the agency of solar evaporation. This change in the process of manufacture indicates a change in climate, and in California, where salt occurs in every known form, 97 per cent. is derived from sea water along the coast, solar evaporation, favoured by climate, proving effective. A season as long as 210 days without rain, has been experienced on the shores of San Francisco Bay. But apart from the material assistance derived from a natural fuel, the main reason for the use of sea water is that the population generally is settled along the coast, providing a brisk market with the minimum cost of transportation.

A very interesting problem of the future will be the struggle between the evaporation method of producing salt and the utilisation of the important deposits in the State, that at present remain unworked, owing to the cost of distribution of the manufactured article. California possesses not only salt in solution in the brines of salt springs, in salt lakes and marshes, and in saline streams, but in the Great Basin region salt may be collected by simply scraping the crust. In the Avawatz Mountains, rock salt outcrops in a zone some five miles in length, massively crystalline, and chemical analyses show the salt to be more than 98 per cent. pure. Another distinctive feature is the district known as Searles Lake. Here the salt crust occupies a circular area, some 12 sq. miles in extent. The depth of the salt as shown by drillings is fairly uniform, ranging from 60 ft. to 140 ft., and averaging 70 ft. to 75 ft. in the main part of the deposit. The salt is, in effect, a consolidated mass crystallised from an evaporating mother liquor, in which other salts are still immersed. The lake is one of the most promising sources of domestic potash salts. In another lake it is computed that 90,000,000 tons of common salt are dissolved, and more than 10,000,000 tons of potassium chloride. Such immense stores, easy of acquisition, cannot but effect the old manner of preparation, and will gradually bring about a revolution in method. The utilisation of bye-products may complicate the issue, but the main struggle will lie between the costs of labour and fuel on the one hand, and those of organised transport on the other. The Bureau of Mines is rendering a very useful service, both to those engaged in the industry, and those who may contemplate entering the business, by the collection and dissemination of information. The Statistics of Salt Production to be published under the auspices of the United States Geological Survey will probably indicate the direction from which a solution of the general problem may be expected.

Since evaporation can be effected or hastened by four different methods, either by (1) solar heat, (2) direct heating applied in open kettles and pans, (3) steam evaporation in jacketted kettles and in graiuers, and (4) by the vacuum pan, it will be convenient to accept this division of the general

FIG. 1. SALT VATS WITH COVERS REMOVED IN SOLAR EVAPORATION PROCESS.

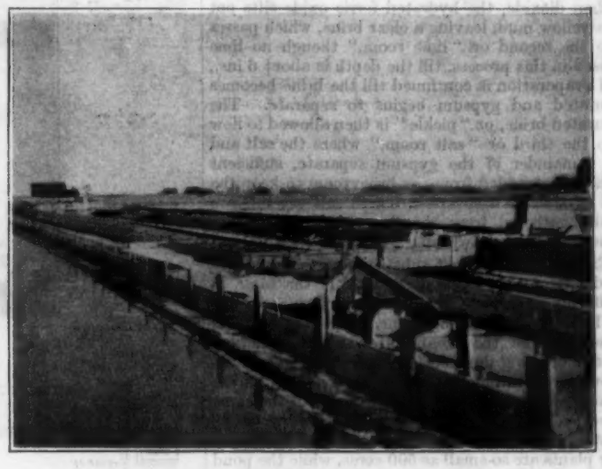


FIG. 2. BRINE RUNNING FROM POND TO POND BY GRAVITY.

* "Technology of Salt Making in the United States," by W. C. Phalen. Bureau of Mines, Van H. Manning, Director. Washington Government Printing Office, 1917.

evaporation processes. Solar heat, as already intimated, is mainly confined to the West, but the method is still practised at Syracuse, New York, a relic that has survived from earlier days. The shortness of the season, April to November, the increasing value of the enormous acreage covered by the plants, the higher charges for fuel, lumber, &c., are yearly diminishing the profits of manufacture, and the disappearance of the industry is apparently only a matter of time. The general process is of an extremely simple character and the method originally adopted has undergone alteration only in details. The natural brine, containing 17 per cent. to 20 per cent. of sodium chloride, is submitted to the sun's rays by exposure in three successive vats, technically known as "rooms." These rooms are 18 ft. wide, and continue the length of the salt yard, perhaps 400 ft. to 500 ft. (a view of a range of such rooms is given in Fig. 1, on page 77). Movable covers in 16-ft. sections (288 sq. ft. in area) are provided to the vats, these covers being taken off during sunshine and replaced in rainy weather.

The first vat of the series—named the "deep room"—has a depth of 12 ins. or 14 ins., and is mainly used for storing. Here, due to the escape of carbon dioxide, the hydrated ferric oxide sifts out as a yellow mud, leaving a clear brine, which passes into the second or "lime room," though no lime is used in this process, till the depth is about 6 ins., and evaporation is continued till the brine becomes saturated and gypsum begins to separate. The saturated brine, or "pickle" is then allowed to flow into the third or "salt room," where the salt and the remainder of the gypsum separate, sufficient pickle being added from the brine room to keep the salt crystals well covered. These salt crystals are finally gathered from the floor after the mother liquor has been drawn off.

Except that we must substitute acres for square yards, the process of salt making is the same in California as in New York. Details vary according to locality and management, and the brine is collected from the ocean, often by tidal action, instead of being pumped from wells. The exposure to sun's rays in successive tanks, or ponds, as the pickle increases in strength, is made with the same object as before, followed by the harvesting of the crystallised salt that has settled out of the brine. Few plants are so small as 500 acres, while the pond area of others will exceed more than 2,000 acres. This does away with the possibility of "covers," but the protection is not needed, as in a typical season the rainfall is only about 4 in., while the amount of evaporation is nearly 40 in. But operations on a large scale call for special treatment. The ponds have mud floors and are separated from each other by low embankments, the brine being run from one pond to another by gravity. Fig. 2, on page 77, shows a series of such ponds. Where pumping is necessary, Archimedean screws propelled by windmills are generally employed.

Harvesting off the rough floors is a matter of difficulty. Usually, the salt deposit is collected to within 2 in. of the mud floor, the remainder being gathered and sold for making ice cream, and for stock. But, in spite of these precautions, the salt, on coming to the mills, is found to be contaminated with "bittern" and dirt of various kinds. Occasionally the salt is re-dissolved and treated by the vacuum-pan process, but more frequently it is washed in hot brine and stacked in heaps to dry. These stacks are constructed with as small a surface as possible, in order to reduce the area exposed to rain, and to facilitate the breaking up of the hard external surface. The outside crust may become so hard, that the cost of breaking up a small stack is more than the salt is worth, and small stacks have been left derelict on that account. The firmness of the crust depends in some measure on the quickness of crystallisation. At San Diego a pickaxe has to be used to break up the salt on the crystallising pond. Fig. 3, annexed, is a view showing the salt crystallisation referred to.

Till recently, the bittern from the crystallising ponds has been allowed to run to waste, and the prospect of recovering potash and other valuable salts has been a pleasant dream rather than a practical proposition. But as the accompanying tables show, the analyses disclose a fair proportion of both the chloride and sulphate of magnesium, and other valuable ingredients are not negligible.

Typical analyses of bitterns from sea water, Californian coast :—

Radicals in Grams per Litre.

Constituent.	Sample 1.	Sample 2.	Sample 3.	Sample 4.	Sample 5.	Sample 6.	Sample 7.
K. ..	8·2	13·4	13·2	14·6	21·5	35·0	11·8
Na ..	80·0	75·8	38·8	27·7	9·1	93·6	60·1
Ca ..	1·2	2·2	0·6	0·5	1·0	0·2	1·1
Mg ..	24·0	23·4	50·6	62·7	79·4	5·6	43·0
Cl ..	179·2	176·6	179·4	183·3	220·1	180·4	190·8
SO_4 ..	30·0	31·4	53·6	74·2	62·0	29·0	55·8
Br ..	3·0	3·0	3·0	3·0	2·0	2·0	2·8

FIG. 3. SALT CRYSTALLISATION IN PREPARED PONDS.

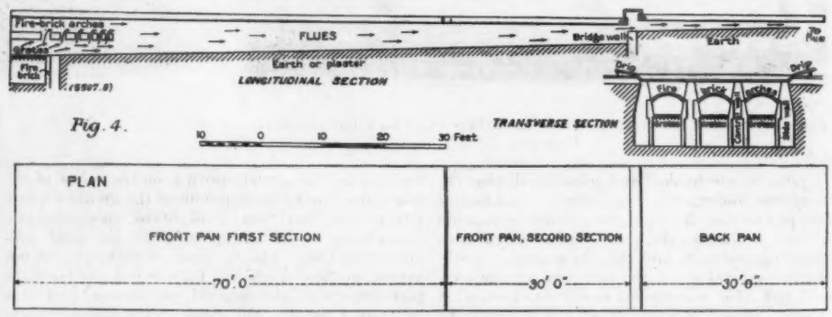


Fig. 4.

FIG. 4. SECTION AND PLAN OF PAN BLOCK.

Radicals in Percentage of Anhydrous Residue.

Constituent.	Sample 1.	Sample 2.	Sample 3.	Sample 4.	Sample 5.	Sample 6.	Sample 7.
K. ..	2·51	4·11	3·89	3·99	5·44	10·03	3·22
Na ..	24·57	23·27	11·45	7·57	2·30	26·83	16·41
Ca ..	0·37	0·68	0·18	0·14	0·26	0·06	0·30
Mg ..	7·38	7·18	14·92	17·13	20·09	2·47	11·98
Cl ..	55·03	54·20	52·88	50·07	55·71	51·72	52·10
SO_4 ..	9·22	9·64	15·80	20·28	15·69	8·32	15·22
Br ..	0·92	0·92	0·88	0·82	0·51	0·57	0·76

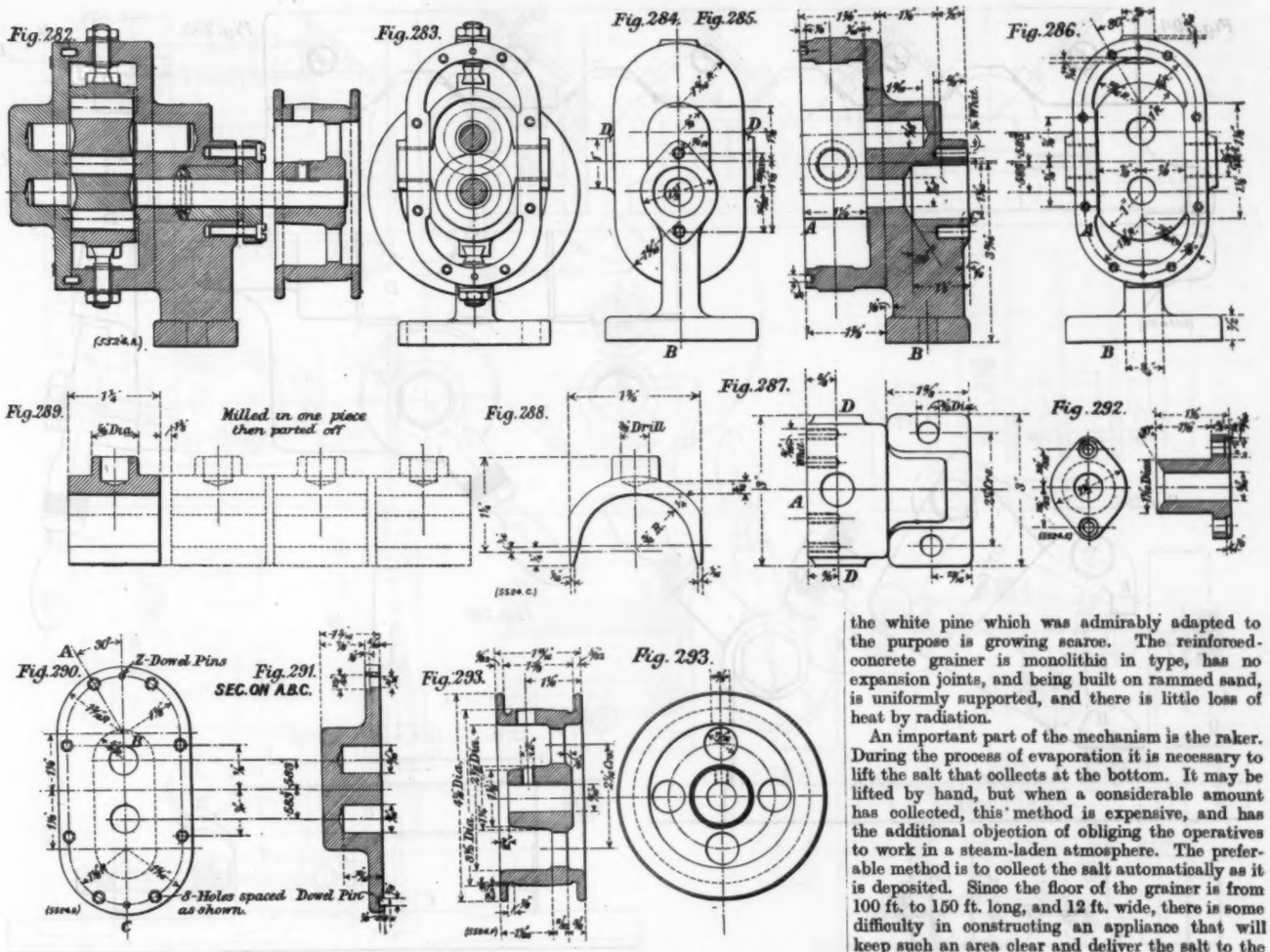
The samples from several refining works along the coast, show considerable variation, but the relatively large content of potassium suggests that the bittern might be evaporated and utilised in the manufacture of low-grade fertilising material, such as manure salts and kainit.

The process followed in Utah, where the water from the Great Salt Lake has a salinity of about 15 per cent., but varying considerably with the changes of level in the lake, does not differ from that on the Californian coast. Pumping begins in April, at the rate of about 5,000 gals. a minute for 16 hours a day, and is continued till the middle of September. The settling ponds, where the brine remains for five or six days, cover 75 acres, and the evaporating ponds about a square mile, whence the brine passes to the harvesting ponds, the whole operation being completed in about 30 days. The average crop is about 3 in. of salt, and may reach 5 in.

Evaporation by the application of direct heat, involving fuel combustion, is in one or other of various forms the practice that obtains most largely. The open kettle process is still followed in some localities, and just as Syracuse, New York, furnished an example of solar heating, the same locality may serve to illustrate the earliest application of the direct heating process that imitates more or less closely the original plan of boiling a kettle on an open fire. In the early days, two or more kettles were set on an arch of masonry and heat applied beneath. With increasing business, the number of kettles grew, till a hundred or more, constituting a "block," were suspended in two parallel flues or arches, terminating in a chimney. Those nearest the fire would contain 150 gals., and the more remote, 100 gals. of brine. Troubles came with increasing numbers, for the kettles nearest the fire not only collected a thick coating of calcium sulphate, difficult to remove, but were too intensely heated, and some protection had to be provided for the kettles that the heat of the fire first reached, a procedure not conducive to economy of fuel. Owing to inherent difficulties in this method of firing, it has been estimated that with a given quantity of good fuel, not more than two-thirds as much water was evaporated in a kettle block as could be evaporated in a properly-constructed boiler. Such a system of heating stands self-condemned, and became obsolete, but the methods of operation that were employed find still a general application in smaller plant.

The open-pan method, which supplanted that of the kettle, employs a series of shallow vats, formed of riveted wrought-iron plates, about ¼ in. thick, and furnished with flaring sides. These vats or pans are usually about 120 ft. long, 20 ft. to 30 ft. wide, and 12 in. or 18 in. deep, and divided into three

TEMPLETS, JIGS AND FIXTURES.



FIGS. 282 TO 293. GENERAL VIEWS AND DETAILS OF ROTARY SUDS PUMP; THE BROOKE TOOL MANUFACTURING COMPANY, LIMITED, BIRMINGHAM.

compartments, as shown in Fig. 4. The brine is first heated by the hot gases from the flues in the back pan, whence it is syphoned into the front pans. This removal permits a better control of the grain of the salt by reducing the commotion in each compartment. When sufficient salt has separated in the front pan, the deposition is removed by hand or by mechanical rakes to the drain board, built along the flaring sides, and allowed to drain. In the meantime, the front pan is refilled with brine from the back pan, which, in turn, is refilled from the settling tanks. These latter tanks are necessary for the preliminary treatment of the brine as received from the wells. By exposure to the air the brine parts with much of its hydrogen sulphate and some of the iron compounds. A thin emulsion of lime is added, and thoroughly mixed with the brine, in order to precipitate the remainder of the iron salts, which, if not removed, would discolour the product. Soda ash is sometimes added where a high-class salt is needed, the object being to secure a clear liquid before passing it to the evaporating pans.

Evaporation in jacketted kettles presents no new feature, but as the walls may be made thinner, a more economical transmission of heat is secured, and the greater uniformity of heat preserved during the process ensures a fine grain and a good quality of salt. In the grainer process, however, a new principle is involved. On the application of heat to a solution containing various salts, these different salts will crystallise out, when in the gradually-diminishing liquid each reaches its point of saturation, and when all the water is driven off, a series of deposits will remain in which the salt that first reached saturation will be at the bottom, and the most soluble at the top. If the supernatant liquid could be removed after the first deposit was formed, and before the other salts reached their respective points of saturation, the deposit of the first salt would be very pure. This is the principle of the ordinary process of purification by fractional crystallisation. The same result may be practically reached by adding more of the original mixed solution, before the second salt begins to crystallise. By such procedure, the concentration of the first salt is decreased less than that of the others, and the subsequent deposition is less retarded, a thicker and thicker deposit of the first salt being caused by each addition, till the concentration of the other salts in the solution becomes so great, that they also are deposited. This is the principle of separation followed in the "grainer" process.

The mechanical working is as simple as the theoretical principle. It consists in passing live or exhaust steam through metal pipes immersed in the brine to be evaporated. The brine is contained in the grainer, a long, narrow, shallow vat, which can be built of either wood or metal supported on a framework, or of concrete or cement on a foundation of sand. It is important that the grainer remains brine-tight under great differences of temperature. Wooden grainers have many advantages. They are easily made and withstand the action of the brine, do not shrink, and can be reckoned to give good service for five years. The reinforced concrete grainer is displacing the wooden type, for one reason the white pine which was admirably adapted to the purpose is growing scarce. The reinforced-concrete grainer is monolithic in type, has no expansion joints, and being built on rammed sand, is uniformly supported, and there is little loss of heat by radiation.

An important part of the mechanism is the raker. During the process of evaporation it is necessary to lift the salt that collects at the bottom. It may be lifted by hand, but when a considerable amount has collected, this method is expensive, and has the additional objection of obliging the operatives to work in a steam-laden atmosphere. The preferable method is to collect the salt automatically as it is deposited. Since the floor of the grainer is from 100 ft. to 150 ft. long, and 12 ft. wide, there is some difficulty in constructing an appliance that will keep such an area clear and deliver the salt to the "aprons" at such a rate as to allow it to drain properly before conveyance to the warehouse. If iron is used, the metal deteriorates very rapidly in the brine, and the iron salts formed discolour the product. Chains are unsatisfactory from their liability to break, and other devices have proved equally inconvenient. The most satisfactory form in use consists of a frame work placed within the grainer and entirely submerged in the brine. This framework carries a series of feather scraper blades and travels the length of the grainer near the bottom. This raker is operated by a hydraulic cylinder placed in front of the grainer, and beneath the steam pipes.

(To be continued.)

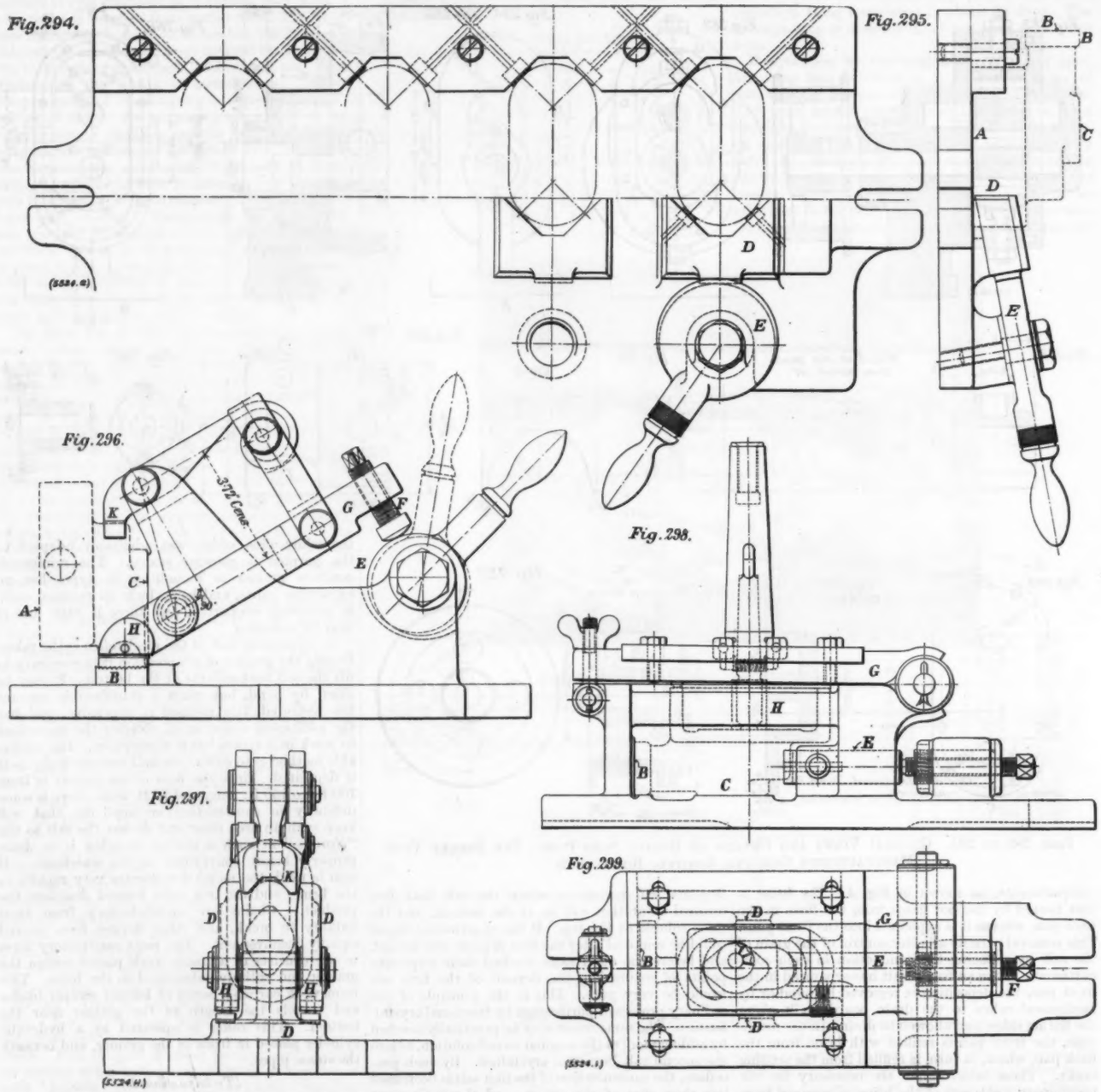
TEMPLETS, JIGS AND FIXTURES. No. IX.

By JOSEPH HORNER.

THE illustrations on the present page and pages 80 and 81 are those of fixtures and jigs designed by the Brooke Tool Manufacturing Company, Limited, of Birmingham, for dealing with the parts of a new patent rotary suds pump. They afford yet another remarkable example of the large amount of scheming and of preliminary unremunerative work that is necessary before even a small article can be manufactured in quantities, with parts interchangeable. A good sum of money has to be spent in drawing office and shops before any return is realised.

The pump is shown assembled in Figs. 282 and 283. The parts dealt with in the fixtures are seen separated as follows: The body, Figs. 284

TEMPLETS, JIGS AND FIXTURES.



FIGS. 294 TO 299. FIXTURES AND JIGS FOR ROTARY SUDS PUMP; THE BROOKE TOOL MANUFACTURING COMPANY, LIMITED, BIRMINGHAM.

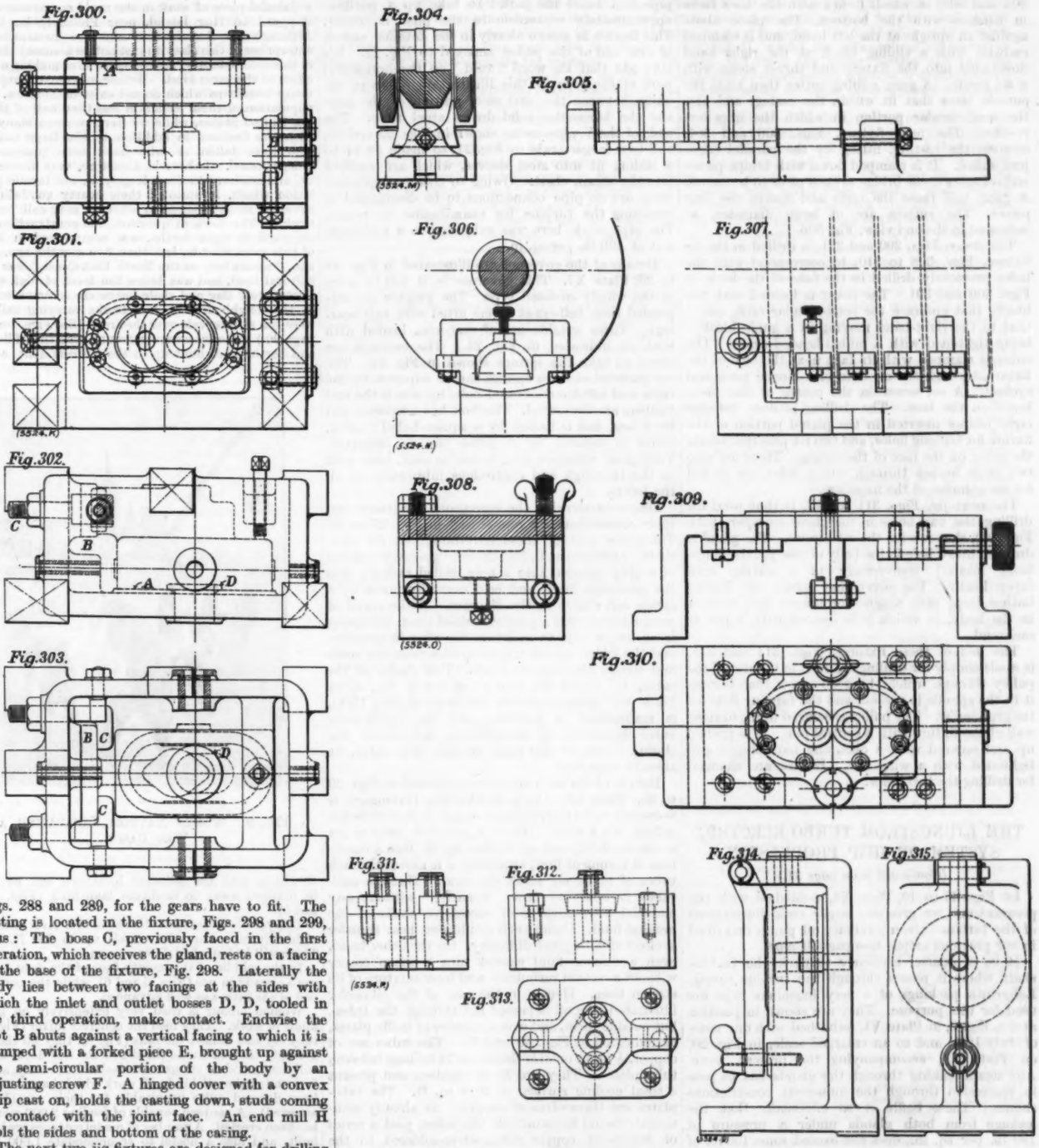
to 287, of cast iron; the concave shoes of phosphor bronze, Figs. 288 and 289, in which the pinions run, and that make a tight fit in the body; the cover, of cast-iron, Figs. 290 and 291; the gland, of cast-iron, Fig. 292; and the pulley, also of cast-iron, Fig. 293.

The first operation on the body is done in the fixture, Figs. 294 and 295. The position of the piece is seen in dotted outline (compare with Figs. 284 to 287). In this, the joint face A, Fig. 285, lies on the base of the fixture. The foot B is to be faced, and the boss C for the gland. Four bodies are dealt with here at one time. Each body is located and clamped by its semi-circular ends, contact with which is made by hardened steel pins disposed two at each end, at angles of 45 deg., Fig. 294. At one end these are carried in a fixed abutment-piece screwed to the base, at the other end a movable clamping piece D is pushed against the casting by an eccentric cam E and lever. The axis of the cam and lever lies at an angle with the horizontal (see Fig. 295), in order to exert a downward pressure on the work to maintain it in contact with the bottom of the fixture, a method that is adopted in many machine vices.

In the second and third operations the portion A, Fig. 285, on which the cover has to be screwed is faced, and also the two bosses, D, Figs. 284 and 287, for inlet and outlet. To set for this, the casting is erected in the fixture, Figs. 296 and 297, with the faces A and D, D, standing vertically, to be milled. The foot, and the boss for the gland, faced in the preceding fixture, furnish the locating faces, the foot resting on the base, and the gland boss in contact with an abutment in the fixture. A hinged lever with a forked end at K, is made to embrace a semi-circular portion of the pump body (compare with the end view, Fig. 284), being pulled down to clamp it by the action of an eccentric cam E at the other end of the fixture turned by a lever; the full-line position of the lever being that of gripping, the dotted-line position that of release. The convex head of a set screw F, which can be adjusted in the end of its lever G, permits of making careful regulation of the pressure. The lever G is connected to the forked-ended lever K by a spiral spring form of joint to render its movements easy. The lever G which carries the convex headed adjusting screw that makes contact with the cam is pivoted at the opposite end to two clamping pieces H, H, that hold down the foot of the body casting to the base of the fixture. As these pieces would be liable to slip in consequence of the diagonal direction of the pressure, their faces are serrated. The body, located and clamped thus by the faces B and C is milled on the face A—the second operation, to receive the cover, and on the faces D, D, of the inlet and outlet bosses—the third operation.

The next stage is that of milling the interior contour of the case, Fig. 286, into which the seatings,

TEMPLETS, JIGS AND FIXTURES.



FIGS. 300 TO 315. FIXTURES AND JIGS FOR ROTARY SUDS PUMP; THE BROOKE TOOL MANUFACTURING COMPANY, LIMITED, BIRMINGHAM.

Figs. 288 and 289, for the gears have to fit. The casting is located in the fixture, Figs. 298 and 299, thus: The boss C, previously faced in the first operation, which receives the gland, rests on a facing in the base of the fixture, Fig. 298. Laterally the body lies between two facings at the sides with which the inlet and outlet bosses D, D, tooled in the third operation, make contact. Endwise the foot B abuts against a vertical facing to which it is clamped with a forked piece E, brought up against the semi-circular portion of the body by an adjusting screw F. A hinged cover with a convex strip cast on, holds the casting down, studs coming in contact with the joint face. An end mill H tools the sides and bottom of the casing.

The next two jig fixtures are designed for drilling the various holes in the casing. In the first, Figs. 300 and 301, the fixture is seen to be provided with square feet which permit of turning it about and standing it on the table of the drilling machine in positions at right angles with each other. The casting is inserted sideways in the fixture, located by the joint face A and by the foot B, and is clamped into contact by the various set screws seen. The fixture is an open one, that is, having no cover, since all the drilling is done through bushes inserted in the sides, which bushes are much longer than those of the usual standard lengths. Ten small holes are drilled in the joint face A that receives the cover (compare with Fig. 286), eight of which are tapping holes, and the other two at the ends are for locating pins. Through the same fixture wall two larger bushes guide the drill for the holes for the pinion spindles, Figs. 285 and 286. The bushes being closely adjacent have their flanges cut away to abut. On the opposite wall is a large bush, Fig. 300, through which the stuffing box is drilled. In the right-hand wall two bushes guide the drills for making the two bolt holes in the foot (compare with Fig. 287). The drilling is followed by reaming.

The jig fixture, Figs. 302 and 303, resembles the last one. It is used for drilling the inlet and delivery holes in the sides, and those in the ends for the setting-up screws for the concave shoes. The feet provided on the fixture permit of setting it truly at right angles on the table by both sides and both ends. The casting is located by the joint face A on the bottom of the fixture and the foot is brought against a facing at the left-hand end, to which it is clamped with two hook bolts, C, C, which are prevented from turning by embracing forks. A shallow boss D which exactly occupies the width between the facings milled in Figs. 298 and 299, positions the casing in the lateral direction. The drilling of these four holes completes the body casting.

The tooling of the seatings, Figs. 288 and 289,

for the impeller gears is done in two operations. The material for four pieces, Fig. 289—two sets—in phosphor bronze, is carried in a fixture, Figs. 304 and 305, in which it lies with the boss faces in contact with the bottom. The piece abuts against an upright at the left hand, and is clamped endwise with a sliding block at the right hand dovetailed into the fixture and thrust along with a set screw. A gang milling cutter then tools the outside faces that fit within the casing, and also the semi-circular portion in which the impellers revolve. The next fixture, Figs. 306 and 307, receives the casting, fitting by the parallel edges just milled. It is clamped down with bridge pieces and set screws, one bridge to each piece to be cut off. A gang mill faces the ends and severs the four pieces. The cutters are of large diameter, as indicated in the end view, Fig. 306.

The cover, Figs. 290 and 291, is drilled in the jig fixture, Figs. 308 to 310, to correspond with the holes previously drilled in the face of the body in Figs. 300 and 301. The cover is located with vee blocks that embrace the semi-circular ends, one—that to the right-hand moving in a guide block—being tightened with a milled-headed screw. The cover is clamped with its face next the face of the fixture, through the medium of a hinged piece and eyebolt. A set screw in the centre of this piece bears on the boss. The drilling is done through eight bushes inserted in the plated portion of the fixture for tapping holes, and two for pins that locate the cover on the face of the casing. There are also two large bushes through which holes are drilled for the spindles of the impellers.

The next jig, Figs. 311 to 313, is that used for drilling the two holes in the gland (compare with Fig. 292), that receive the set screws. The gland is dropped into a hole in the body of the jig, the flange being located transversely in a seating with tapered sides. The cover that carries the drilling bushes drops with tongues or tenons into recesses in the body, in which it is located with a pin at each end.

The last of these fixtures, Figs. 314 and 315, is made simply for drilling the hole in the rim of the pulley through which the grub screw that fastens it to the spindle is passed, and the tapping hole for the grub screw. The pulley is centred in the upright wall of the fixture with a central pin. It is pushed up and secured with a clamping bar, hinged and tightened with a wing nut. Bushes are changed for drilling the two holes.

THE LJUNGSTRÖM TURBO-ELECTRIC SYSTEM OF SHIP PROPULSION.

(*Continued from page* 31.)

IN Figs. 17 to 19, Plate XI, published with the present issue, we give to a larger scale illustrations of the turbine-driven auxiliary oil pump described in our previous article (see page 31 *ante*).

It is, of course, necessary to pack the turbine shaft where it passes through the turbine casing. Labyrinth packings of a very ingenious type are used for this purpose. They are shown in position at *v v*, Fig. 2, in Plate VI, published with our issue of July 12th, and to an enlarged scale, in Fig. 20, on Plate XI, accompanying the present issue. Any steam leaking through the glands has to pass in succession through the numerous constrictions shown. These baffle it so effectually that the leakage from both glands under a pressure of 180 lb. per sq. in., does not exceed some 150 lb. of steam per hour. The leakage steam is trapped by the pipe shown to the left in Fig. 3, Plate VI, already referred to, and is led off to a special condenser. The gland is assembled, with practically no clearances, wearing its own when set to work. Where they touch, the fine ends of the fins simply rub away, their mass being too small to occasion any distortion of the gland by the heat developed in the process.

In Figs. 21, 22 and 23, Plate XI, we show some further details of the Y pipe, by which the steam passes from the main stop-valve to the turbine valve-chests. This pipe has to pass through the exhaust space, and to reduce convection losses, it is air-jacketted. The jacket is of copper made in halves which were brazed together after being placed on the main pipe. At the two ends of the jacket the metal is turned inwards so as to grip the pipe and cause the jacket to take up a position approximately concentric to the pipe it covers. This feature is shown clearly in the detailed sketch of one end of the jacket annexed to Fig. 22. We may add that the word "weld" on the horizontal part of the pipe in this illustration refers to the union between the cast steel portion of the pipe and the horizontal solid drawn steel tube. The ends of the Y pipe are as shown in Figs. 22 and 23, and to a larger scale in Fig. 21, so made as to be a sliding fit into steel sleeves, which are caulked into the steam chest. Owing to this arrangement, there are no pipe connections to be dismantled in removing the turbine for examination or repair. The pipe work here was subjected to a hydraulic test of 400 lb. per sq. in.

Details of the governor are illustrated in Figs. 24 to 26, Plate XI. This governor is, it will be seen, of the wholly-enclosed type. The weights are suspended from bell-crank levers fitted with ball bearings. These weights are of cast-iron, loaded with lead, as indicated in Fig. 25. The castings are bored to take the springs shown in Fig. 24. The compression of these springs can be adjusted by the right and left-hand screwed bolt, by which the end washers are connected. This bolt has a squared end for a key, and is locked by a square-holed washer, which is secured by a spring clip as indicated. Very great attention has, it will be seen, been paid to the thorough and continuous lubrication of all the joints.

Diagrams showing the emergency governors and their connections are reproduced in Figs. 27 to 29. There are two of these governors, one for each shaft. As shown at B, Fig. 28, each governor consists of a plug inserted into a hole drilled radially into the generator-shaft, and held normally home by a spring not shown in the diagram. If the speed of revolution exceeds a pre-determined limit, the spring is no longer able to maintain the plug in position, and the latter accordingly protrudes from the shaft and strikes the trigger shown. This slacks-off the cable, by which the stop F, shown in Fig. 5, on Plate VII (published with our issue of July 12th), is maintained in position, and the equilibrium valve E moves up accordingly, and effects the closing down of the main turbine stop-valve, as already explained.

Details of the oil-cooler are reproduced in Figs. 30 to 35, Plate XI. As is well-known, turbulence is necessary to any rapid interchange of heat between a fluid and a solid. It is not, however, easy to get a viscous fluid, such as lubricating oil, into a condition of turbulent flow, especially if it moves through tubes of relatively small diameter. Through such tubes it tends to flow "linearly," without any material inter-mixture of successive shells of the moving fluid. Under such conditions, heat transfer is effected with great difficulty. On the other hand, even a viscous fluid cannot turn a sharp corner without a certain turbulence and inter-mixture of its stream lines. Hence, in the case of the oil-cooler illustrated, the oil is passed not through the tubes, but outside them, and over a number of baffle plates, as indicated in Figs. 30 and 34. The tubes are of copper, $\frac{1}{2}$ in. in outside diameter, 34 in. long between tube plates. They are 31 in number, and present a total cooling surface of 10·8 sq. ft. The tube-plates are themselves of copper. As already mentioned, the oil flows outside the tubes, past a series of baffles of copper-plate, silver-soldered to the tubes. Successive baffles make angles of 120 deg. with each other, as indicated in Fig. 35. The spacing of the baffles is shown in Fig. 34.

One of the tube-plates is, it will be seen, free, so that the tubes can expand without restraint when the temperature varies. The water-box on the left is divided into two compartments by a vertical partition. The water enters on the one side of this diaphragm, and leaves on the other. Thermometer pockets are provided for taking the temperature of the in-going and out-going lubricant, and of the water supply and return. The cooler was subjected to an hydraulic test of 140 lb. per sq. in. after completion.

(*To be continued.*)

A NEW FURNESS SHIPYARD.

WE recently (see page 731 *ante*) gave an account of a wonderful piece of work in the rapid construction of a shipyard on Hog Island, near Philadelphia, U.S.A. Although our American cousins are unsurpassed in enterprises of this class it must not be assumed that we, in this older country, are not capable of making a great effort of the same kind. We are, of course, subject to many handicaps which do not exist in America. The population of these islands is less than half of that of the United States, while we have twice as many men with the Colours, in addition to the large numbers who have fallen or who have been permanently incapacitated. Labour is, therefore, very scarce with us, and we have to draw largely on our female population which, in spite of their hearty goodwill, can never be really efficient in what we may call "navvy work." The work in question, the construction of a shipyard of eight berths, was commenced in March of this year, that is, less than five months ago. The site, "somewhere on the North East Coast," was agricultural land, and was below the level of high water. Fortunately slag and shale heaps are common enough in the neighbourhood, and banks carrying railways were run at intervals over the area. (See Figs. 1 and 2, page 90.) The intervening ground was then filled up and berths were built up to the embankment, a part

FIG. 9. WOMEN NAVVIES EXCAVATING A WET BASIN.

of which, with the adjacent foreshore, will have to be dredged away to facilitate launching (Figs. 3, 4 and 5).

The yard is situated on the bend of a river, and the eight slipways can take vessels up to 650 ft. long. These will be launched down-stream.

In the middle of this month four of the eight berths were already in use (Figs. 5 and 6), while the concrete bed of the fifth was well advanced.

Women labour is used very extensively on many kinds of work. They feed the concrete mixer (Fig. 7); they lay and ballast the rails (Fig. 8), they fill the low ground; they excavate the site of the wet dock, which will accommodate several vessels simultaneously, and in fact undertake all kinds of work which have hitherto been deemed quite unsuitable for their sex (Fig. 9 annexed). A canteen capable of feeding 2,000 workers has been erected. A number of model cottages are being built, and also a hostel to accommodate 1,000 men. The ships will be "fabricated," the bulk of the work being fitted together in the steel works in the district and delivered on to the site in as large sections as possible. It is expected that the first vessel will be launched in November, and it is the ideal of the management to put a ship into the water every fortnight after affairs get into full swing.

The U-boat campaign is drawing to its close. Every day these vessels are hunted "like a partridge on the mountains," and are either sunk or forced to surrender. But unfortunately the ocean bed is strewed with their quarry, and it will take months and years to repair the waste they have occasioned, and to put us into our old position as the carriers of the world. For a long time to come our shipyards must work at high pressure, and every berth laid down will be kept continuously occupied.

THE RECOVERY OF LIGHT OILS AND REFINING OF TOLUOL.

GASMAKERS have had increasingly difficult problems imposed upon them during recent years. While the public demands a gas of high illuminating power, and the metallurgist a good coke, both at low costs, the protests against waste of possible by-products have become more imperative, and the claims for particular products more difficult to reconcile. The war has enormously increased the demand for toluene in particular. Many an engineer may know more about some special distillation or cracking process than about the ways in which the gas-maker meets his problems at present. The conditions are similar in America, and in response to numerous inquiries regarding the recovery of light oils from gases and the refining of toluol, the Bureau of Standards, in conjunction with various authorities, gas makers and manufacturers of plant, issued a report last year, an abstract of which will be generally acceptable. The term light oils is used to designate in the crude state the aromatic hydrocarbons benzol, toluol, xylol, &c., which in the pure state are known as benzene, toluene, &c.; the nomenclature remains, unfortunately, very unsettled.

Gas Sources Utilised.—The three sources of light oils considered are: (1) Coal-gas, (2) water-gas, (3) oil-gas. (1) The distillation in retorts is mostly intermittent; the gases are condensed, scrubbed, washed, purified; some of the aromatic compounds are washed out, the greater portion remains in the gas. (2) Blue gas of about 300 British thermal units per cubic foot is produced by intermittently blowing air and sending steam through a bed of hot anthracite or coke. The gas is conducted into a carburettor chamber set with staggered rows of checker bricks which are heated during the blow period; some gas oil or fuel oil is sprayed into the carburettor while the gas is passing through it, and the blue gas is thus enriched; during this period tar and aromatics are formed; they are partly condensed and removed by washing, but some light oils remain in the gas. Mixed gas, supplied in some American cities, is a mixture of the carburetted water-gas (2) and coal-gas (1), the two plants being separate, but the storing common. (3) Oil-gas is made chiefly in the Pacific Coast States; oil is used, both as raw material and as fuel for heating the checker bricks which are sprayed with the same oil and with steam, gas and lampblack being formed as chief products. The number of gallons of crude light oils found in these gases (all per short-ton of coal carbonised) were: (1) (*a*) Horizontal retorts, 3 gallons; (*b*) continuous vertical retorts (one installation only), 1.8 gallons; (*c*) coke ovens, 2.6 gallons. (2) The light oils made up 10 per cent. of the volume of carburetted gas. (3) No specific data were available, proportions probably as in (1). The percentages of benzol, toluol, solvent naphtha and paraffins in these crude oils were: (1) (*a*) 38, 16, 46, less than 2; (*b*) 15, 15, 58, 12; (*c*) 55, 14, 31, less than 2. (2) 42, 25, 33, less than 2. Thus the coke-oven gas was richest in benzol, giving 1.47 gallons of benzol and 0.35 gallon of toluol, while the horizontal retorts gave most toluol, 0.45 gallon, and 1.32 gallons of benzol. It is not considered advisable to recover the light oils from plants of a capacity of less than 100,000,000 cub. ft. of gas per year; the general survey shows that about 122 plants of an aggregate output of 135 billion cubic feet would be available in the United States, there being 97 billion cubic feet of water-gas, 25 billion cubic feet of coal-gas, and 13 billion cubic feet of oil-gas; light oils were actually recovered only in a few of these plants.

Outline of Processes.—The condensable vapours of light oils are associated in the gas with olefines and paraffins of similar properties, from which they can hardly be separated on commercial lines; the gas manufacture is hence controlled so as to keep paraffins and olefines low, especially as the presence of more than 2 per cent. of paraffins is said to make toluol unfit for the manufacture of high explosives. This suppression of the paraffins, &c., is effected by controlling the temperature and rate of oil injection, and the spacing of the checker bricks, &c.; dirty checker-bricks are believed to favour paraffin formation. The light oils are removed by washing the gas in scrubbers with plenty of some very fluid absorbent oil, which must be cool (about 30 deg. C., 86 deg. F.) to absorb well, and yet a little warmer than the gas to prevent condensation of water vapour from the gas; 10 gallons of wash oil per 1,000 cub. ft. of gas seems to be the required average. The two favourite wash oils are: (1) Straw oil—density not less than 0.86 at 15.5 deg. C., flash-point not less than 135 deg. C. in the open-cup test, Saybolt viscosity at 37.7 deg. C. not more than 70 seconds; when distilled with steam, 500 cub. cm. of the oil should, from the same amount of condensed steam, not deposit more than 5 cub. cm. of the oil; and vigorously agitated with 2.5 times its volume of sulphuric acid of 100 per cent. for 5 minutes the oil should not lose more than 10 per cent. by volume after standing for 2 hours. (2) Creosote oil from coal tar, not containing more than 7 per cent. of naphthalene and not yielding more than 5 per cent. by distillation up to 200 deg. C., and not less than 90 per cent. up to 300 deg. C.; the viscosity should not increase much on cooling down to 4 deg. C. Ordinary gas-oil and water-gas tar are used to a certain extent as cheaper wash oils, but their olefines and paraffins contaminate the products.

The wash oil is afterwards "stripped" of its light oils in continuous (or intermittent) stills, from which the vapours pass through chambers in which they meet descending sprays of more charged wash oil; the light oils are then condensed, together with some steam, naphthalene, sulphur compounds, &c., and also wash oil. The refining of the crude oils obtained takes place in stills fitted with rectifying columns, dephlegmators or planers; the first "cut" at about 100 deg. C. yields "benzol"; the following fraction up to 120 deg. C. yields "toluol"; what passes at higher temperatures is "solvent naphtha." The practice varies, however; sometimes no separation of the crude benzol and toluol is attempted in the first instance. In any case the crude oils are treated with strong sulphuric acid, caustic soda and water before redistillation; if the final densities are too low, paraffins, &c., may be present. In some parts of the United States where gas is still largely used directly as illuminant, the profitable depletion of the gas of its light oils and the subsequent enrichment to secure proper candle-power and calorific power remain important considerations.

Apparatus. Scrubbers.—We pass to apparatus and details. The scrubbers, in which the light oils are absorbed by the wash oil, are of different types. The rotary scrubber is a horizontal cylinder so divided into narrow cross-compartments by vertical partitions all through, fitted with central holes, and alternating with partitions reaching half-way up, that the gas baffles, wooden discs built up of slats, attached to the rotating central shaft, keep the wash oil in the lower half of the cylinder moving in a thin stream inward or outward, but not across the discs; gas and liquid enter at different ends of the scrubber. The bubble-type scrubber is built up of superposed cast-iron sections, each provided with a circular port with raised edges; the port is covered by a bell or hood which is kept sealed by the washing liquid; the gas enters from below, the washing oil from above. The spray-type scrubber is similarly arranged, but there are no hoods, the liquid being sprayed at the top through a perforated revolving cone. The hurdle-tower scrubber, the most common type at present, consists of grids or hurdles, made of white pine slats, 5 in. high, 1 in. wide, superposed in vertical cylinders about six times as high as wide; the wash oil is sprayed in at the top through nozzles. In one plant which can wash 10,000,000 cub. ft. of gas per day [this plant will be referred to in the other examples], the hurdle tower has a height of 75 ft., a diameter of 11 ft., and contains 84 hurdles in four banks of 21 each, the banks being separated by spaces of 3 ft., and spaces, 5 ft. and 8 ft. high, are left at the top and bottom for the 12 oil nozzles and the tank. The usual scrubber capacity allowed for seems to be 30 cub. ft. per 100 cub. ft. of gas to be washed per hour. Trays filled with coke are also utilised in scrubbers; there may be several scrubbers in series or parallel.

Heat Exchangers.—Large plants are generally provided with heat exchangers of two types. The vapour-to-oil heat exchanger is a steel cylinder, 8 ft. long, 4 ft. wide, *e.g.*, for a daily scrubbing capacity of 10,000,000 cub. ft., containing 150 tubes, 2 in. in diameter, through which the cold oil charged with gas circulates as coming from the scrubber; the hot gas (from the still to be mentioned) plays about the tubes, being directed by baffle plates. The benzolised oil leaves this exchanger—the type is practically controlled by one firm, it is stated—at 72 deg. C. The flow in the oil-to-oil heat exchanger is arranged on the opposite principle. The benzolised oil from the first exchanger wets the outside of pipe coils through which the debenzolised oil from the still is circulating. In some apparatus wide pipes, joined in sections, contain several smaller pipes; there are eight 10-in. pipes containing fourteen 4-in. pipes, *e.g.*, the overall length being 26 ft., the height 7 ft., width 3 ft. The temperature of the benzolised oil at the outlet of this exchanger is 94 deg. C., that of the debenzolised oil 87 deg.

Superheater and Stripping Still.—From the exchanger the benzolised oil is taken to the superheater (or preheater), which is again of the tubular condenser type. The steel cylinder—generally in duplicate on account of corrosion—is 10 ft. long by 4 ft. diameter in the plant referred to, with 160 tubes of 2 in. diam.; steam flows through the tubes, the benzolised wash oil around them being guided by baffle plates, and leaves at about 145 deg. C. to enter the continuous stripping still. This still consists of an upper and a lower portion, the upper 4½ ft., the lower 6 ft. diameter, each built up of horizontal sections of cast-iron of the same type as the bubble-scrubbers; the edges of the bells are not serrated, however. The benzolised oil enters at the base of the upper portion of a section, which serves as rectifier, and flows down the 12 sections of the lower portion, acting as sealing liquid for the steam which forces its way upwards; the light oil vapour escapes at 104 deg. C., whilst the debenzolised oil leaves at 130 deg. C. From the upper portion the vapours may further be sent through a planer or dephlegmator, the cooling water of which takes up any condensed wash oil.

Wash-Oil Cooler.—The debenzolised oil flows into the oil-to-oil heat exchanger mentioned in which its temperature is cooled to 87 deg. C., and thence to a hot-oil drain tank, and a cooler, the body of which (2-in. pipes, bent in zig-zag, altogether 10 ft. high) are sprayed with water from outside; there are six cooler sets in parallel. The wash oil is then sent to the storage tank and pumped back to the scrubbers.

Condenser, Separator, Crude Rectifying Stills.—The crude vapours of light oil pass through the vapour-to-oil heat exchanger to the inner tubes of a condenser (9 ft. by 4 ft.), through the outer tubes of which water circulates, and thence into a water-oil separator. The light oil is pumped into the crude rectifying still consisting of boiler, rectifying column and dephlegmator. The boiler (capacity 5,000 gallons, 16 ft. long, 7½ ft. diameter) contains 2-in. steel coils and a safety valve; live steam may also be admitted through perforated pipes, and vacuum connections are provided; a run lasts 24 hours or more; the residue of wash oil and naphthalene is sent to the naphthalene pans. The vapours pass into the rectifying column of the bell type, which is mounted on the top of the boiler; it is 12½ ft. high, 4 ft. diameter, and consists of 10 sections. On the top of this column is the dephlegmator or planer, 5½ ft. long, 3½ ft. diameter, containing 148 water tubes of 1½ in. Sometimes the crude rectifying still and the stripping still (previously mentioned) are combined; this is not done in plants for more than 40 gallons of light oil per hour (3,000,000 cub. ft. of gas per day), and in plants for less than 15 gallons per hour fractionation of the oil at the works is generally not advisable.

Agitator and Rectifying Still.—The vapours of benzol, toluol and solvent naphtha enter a condenser (8½ ft. high, 3 ft. diameter, with 90 tubes of 1¼ in. for the water) and separator; further, one of two sampling tanks (100 gallons), and then the agitator, a cylinder 6 ft. high, 8 ft. diameter, of steel lined with lead, with conical bottom, in which the condensed liquid is washed for about an hour with strong sulphuric acid by the aid of paddles; the olefines settle in ½ hour at the bottom, the sludge being run off and the acid recovered. The benzol and toluol are washed with water; the agitator is then charged with caustic soda, and the washing is renewed. The neutralised light oils are then pumped through tanks into the rectifying still, which again consists of boiler, rectifying column and dephlegmator, the columns being higher than in the crude still, and the still larger on the whole. Distillation between 80 deg. and 81.5 deg. C. yields benzol (benzene boils at 80.36 deg. C.), between 110 deg. and 111.5 deg. C. toluol (toluene boils at 111 deg. C.)

General Features.—The report further discusses space required, storage, technical control, testing, safety arrangements, time and cost of erecting plant, and the working of small plant. No definite cost figures are given. Among the conditions for efficient working are ample storage capacity of raw materials and products to meet delays in transport facilities, ample supply of water, and careful control. Since the heavy benzol vapours are apt to spread on the ground over considerable distances, the buildings for light-oil recovery plant should be removed from all others and be bricked up as individual units; the stills should be at least 200 ft. away from any source of flame. The poisonous character of the vapours also calls for special precaution; the safety valves in the stills should be set to blow at pressures of 10 lb. per square inch, tank cars, &c., should also be provided with safety valves, and all tanks should vent to the atmosphere.

SPITZBERGEN COAL.—The Swedish Superphosphate Company is on the point of despatching an expedition to Spitzbergen in order to investigate some coal fields there. A State subvention of about one-third of the cost of the expedition is reckoned upon.

AMERICAN SHIPBUILDING CONTRACTS.—Norwegian owners have recently received offers from American yards for the building of steel steamers "in regular turn," with delivery as early as the beginning of next year. Prices are about 215 dols. to 220 dols. per ton, and the American offers state that the permission of the Shipping Board for building for foreign account has been secured. The vessels, however, would have to sail under American flag for the duration of the war, but as soon as the war is at an end, the vessels would immediately be transferred to the foreign flag. These offers have been received with scepticism at least in some influential Norwegian quarters, and are not likely to have the desired effect.

INDUSTRIAL NOTES.

On the 19th inst., the Ministry of Munitions issued a statement to the effect that a labour dispute which might lead to a serious situation had begun at Coventry and other centres. A large number of munitions workers had handed in notices. Owing to the scarcity of skilled labour in the country created by the needs of the Army and the grave emergency of the war, added the Ministry, it became necessary some time ago to make sure that the skilled labour available was fairly shared among munitions firms, and in some cases to place a limit on the number of skilled workers which particular employers and firms were entitled to engage. The Ministry of Munitions, after a full explanation had been given to the responsible trade-union leaders, issued instructions, under their legal powers, limiting for the present the right of employers in about 100 firms to add to the number of men on their staffs.

This action of the Government was, and remains, absolutely necessary for continuing a proper supply of munitions to the armies. It affects the employer to a far greater extent than any individual workman. The workman's right to leave his employment and to obtain work of national importance still remains. There is no question of reimposing the leaving certificate. Without the power to regulate to a certain extent the apportionment of our available labour among the different firms engaged on various classes of war material, the Ministry further stated, it will be quite impossible for the output of munitions to be maintained. Moreover, the position of munitions workers at the present time is one of exceptional privilege. It is already hard that men between 40 and 50 should be called up for the army whilst so many younger men are left in the munitions factories. It is only the fact that these younger men are needed at their work and are loyally willing to do their work which has induced the nation reluctantly to put up with what is, from many other points of view, unfair. The Ministry then expressed the hope that the high standard and fine record throughout munitions industries during the war and especially during these months of extreme national danger would not be marred by a dispute which, if prolonged, must necessarily lead to grave consequences.

On the same day, the 19th inst., the Executive Council of the Amalgamated Society of Engineers held a conference with the Ministry of Munitions, who stated: (1) That the object of the Government was to secure the fullest and most economical use of the labour, both skilled and unskilled, now available in the country for the production of munitions, and, further, to distribute this labour as equitably as the circumstances permitted and demanded among the various firms. (2) That the need for the embargo scheme arose from the fact that large numbers of men had already been recruited and that the munitions supply must be maintained by the reduced numbers. (3) That up to the present the embargo had been applied to less than 100 out of the 32,000 firms on the official list dealt with under the Munitions Area Recruiting scheme. Further, that it was not the intention to make this prohibition of general application, but to apply it to cases as the need was shown. It was, however, indispensable that it should be proceeded with.

The Executive Council of the Amalgamated Society of Engineers, who were anxious to avoid any stoppage of work in the country, expressed the wish that this statement be generally known among their members, as they hoped it would largely remove the fears that have led to the present uneasiness. They urged all their members at this critical juncture to remain at their work.

Mr. Langton, of the Ministry of Munitions, had several meetings at Coventry on the 21st inst. A resolution was handed to him by the local committee in the following terms: "If Mr. Langton is prepared to negotiate the administration of the restriction scheme in districts, and is prepared to recommend a national conference to consider the question of the utilisation of skilled labour, we will, upon the acceptance of the recommendation of the said conference, accept the mayor's suggestion as chairman of the Local Advisory Committee to recommend our members to suspend their notices."

The following reply was given by the Ministry of Munitions to the resolution:—

"Mr. Langton is authorised by the Minister of Munitions to say that the Ministry of Munitions is in close and constant touch with the responsible leaders of the trade unions, both directly and through the Ministry of Labour. It is open to the Trade Union Advisory Committee or any branch of it specially affected, to discuss the administration of any scheme affecting labour which they desire to raise. While the Government's considered policy in the matter of the embargo scheme cannot be a matter for discussion, should representations be made by the properly accredited bodies, both of the engineering employers and trade unions, as to the necessity for a further conference on the better utilisation of skilled labour apart from the embargo, the Ministry would be prepared to enter into discussion with those bodies and such added representatives as may be thought advisable. The Ministry of Munitions cannot carry on the supply of munitions to the troops without the embargo in cases where the need is shown, and without reasonable powers to distribute the skilled labour according to the vital war needs. It should be noted that the embargo scheme was fully explained to representative bodies of both engineering employers and trade unionists."

A poster in the following terms was despatched by the Ministry of Munitions on the 21st inst., to be displayed at Coventry, Manchester and Birmingham:—

"The threatened stoppage of work is not an ordinary trade dispute between employers and workmen, but an attempt to overthrow the policy of the State in a time of national danger. Many who support it are acting under misapprehension of the real issues.

"The Government's only object is to use the skilled labour of the country so as to give the greatest help to our armies at the front.

"A stoppage of work now will do much injury to our cause during the most critical battles of the war.

"Any person who is guilty of inciting others to leave work or takes any part in organising the strike renders himself liable to very serious penalties under the Defence of the Realm Act.

"The Ministry of Munitions calls upon all patriotic men to remain at their work, and lend no aid to a movement which may have consequences of the gravest kind."

A meeting held in Coventry on Monday morning, the 22nd inst., passed the following resolution:—

"That this meeting could not accept the Government's letter; further, that we recommend to the workshop representatives' aggregate meeting that we suspend our notices pending national conference of the joint allied trades to which we shall send delegates in order that all skilled workmen shall cease work upon a given date; said conference to be held at an early date."

A meeting at Manchester on Sunday night passed a resolution that the men should not cease work there and then, but should hand in seven days' notice. Shop stewards held meetings in various places in Manchester to tak a vote as to whether, in view of Coventry's decision, notices should be handed in. It was reported that most of the voting was in favour of handing in notices.

Meetings were also held in Birmingham.

Speaking in Parliament last Monday, Mr. Churchill, Minister of Munitions, in reply to Mr. W. Thorne, stated that his attention had been drawn to the terms of a notice as to reduction of the district rate of wages issued by a firm at Coventry. The notice was not official, and the Minister of Munitions was not responsible for its wording. It appeared to be an inaccurate summary of instructions issued by the Ministry of Munitions, and only to have been posted, according to his information, in the works of a single firm in Coventry. There was, of course, no question of any reduction in the district rate of wages. Steps had been taken to make that clear. There was at the present time an unsatisfied demand for skilled men to the extent of between 50,000 and 60,000, for whom war work could be immediately found. Skilled men, therefore, had an enormous choice of employment open to them, and this was not appreciably affected by the fact that in the present scarcity of skilled labour the Ministry could not allow firms who had already more than their proper share to add to their staffs. He had seen the statement of Mr. John Hill, general secretary of the Boilermakers' Society. The action of the Minister of Munitions was no extension of the proposals made in June last. On the contrary, it was clearly foreshadowed by him as one of the safeguards contingent on the abolition of the leaving certificate as far back as August 15 of last year. He did not wish to say that what was taking place in the firms on which an embargo had been placed constituted poaching. Poaching should properly be defined as bribing men away from other firms. He did not make that accusation at all, but overstaffing and the readiness to exaggerate overstaffing belonged rather to the realm of potential poaching, and, therefore, was entirely covered by the statement he made to the House nearly a year ago. All these proposals both for engaging additional war munition volunteers and for restricting overstaffing by certain firms, were fully explained to the Trade Union Advisory Committee in April last and again in June.* The committee was not asked to take the responsibility, which properly belonged to the Government, and he had never sought to throw an unfair burden upon them. At the same time, it was right to say that the result of these conferences led all who were present to the conviction that trade unionists and the workmen generally throughout the country were resolute to repair the damage which the military disasters of March last had caused, and to support the national cause by every means in their power, and especially by liberating men and making munitions. To that conviction the Ministry still adhered with the utmost confidence.

* See ENGINEERING, vol. cv., pages 491 and 702.

The Ministry of Munitions made, last Tuesday, the following announcement regarding the labour situation:

Coventry.—About 12,000 skilled men have ceased work during the day. An aggregate meeting of members of the Amalgamated Society of Engineers and other unions decided that all Amalgamated Society of Engineers' men and skilled men at Coventry should remain out until the embargo is removed.

Birmingham.—The Birmingham Joint Trades Committee made the following proposal: "If the Ministry of Munitions will suspend the embargo for 14 days, we are prepared to recommend our members at to-night's meeting at Smethwick and Birmingham not to cease work, and demand reply by 6 o'clock, failing which Sunday's resolution will be carried into effect and men will cease work at 6 p.m. on Wednesday." The Ministry replied that they cannot consent to a suspension of the embargo.

Manchester.—Notices have been put up in some works that the men will cease work on July 30, unless the embargo is withdrawn. In at least one works the men have refused to cease work or hand in notices.

Lincoln.—Men threatened to cease work on Wednesday at noon unless the embargo was withdrawn.

At the time of going to press we are informed that the strike has spread to Birmingham.

Mr. Roberts, Minister of Labour, addressing, last Wednesday, the London Master Printers' Association, said that if the munitions workers persisted in withholding their labour at a time of extreme national emergency, it was only right that they should lay themselves open to the possibility of being taken into the Army and called up to fight. No young men to-day had the right to obtain exemption on any ground other than that they were doing more valuable work in the prosecution of the war, and if they refused to work without substantial or justifiable reason, then by the ordinary operation of affairs, they became liable to be impressed into military service.

The Ministry of Munitions has forwarded the following for publication:—

It will be remembered that one of the terms of settlement of the London aircraft dispute which arose at the Alliance Aeroplane Company was the holding of an immediate inquiry into the circumstances leading up to the dismissal of Mr. Rock (see page 46 *ante*). This report has now been received. The Minister, having regard to the terms of the report, has taken the following decisions which, together with the report, were immediately communicated to the parties concerned:

1. In view of the finding contained in paragraph 15 of the report to the effect that Mr. Rock's action in the matter was such misconduct as to warrant the immediate termination of the contract of service between him and the company, and that his dismissal was justified, the Minister considers it his duty in accordance with the agreement entered into with the responsible trade union officials by which the dispute was settled, to confirm the dismissal of Mr. Rock. (2) The Minister in furtherance of his decision will instal immediately a new management of the Alliance Aeroplane erecting shop, which will become a national factory. (3) In view of the unrest that the report indicates existed in the works for some time anterior to the strike, the Minister has under consideration the reduction of overtime to be worked.

The following are some recent decisions given by the Committee on Production on cases which have been referred to them by the Ministry of Labour:—

Admiralty Dockyard Employees.—On a general claim by skilled, semi-skilled and unskilled workers for a revision of wages, overtime rates, and other conditions of employment and special claims in respect of certain grades, the committee find that the claim of the mechanics for a flat rate of 54*s.* per week has not been established, and they recommend that the present methods of remuneration should be revised by the introduction of an agreed system of payment by results to be fixed according to the procedure and methods usual in private shipbuilding yards and engineering establishments. With regard to overtime conditions, the committee recommend that the men's claim should

without delay form the subject of a conference between representatives of the Admiralty and of the men, the Admiralty's representatives to be given sufficient authority to enable them to conclude an agreement, subject to ratification as a whole. The committee direct the attention of the Admiralty to the ambiguity of the term "skilled labourers," which includes indiscriminately skilled workers, and men similar to those usually graded as semi-skilled or unskilled, and they recommend a more precise classification as between skilled, semi-skilled and unskilled workmen. The committee also recommend that certain other items of the claim should be discussed between representatives of the Admiralty and the men.

Port of London Authority.—Dock tug engineers, drivers and firemen, aged 21 years and over, are to receive an additional war advance of 7*s.* a week from first pay following May 1.

Shipbuilding Trade (Blacksmiths) Wear, Tees and Hartlepool District.—Blacksmiths on merchant work are to have their piece work prices increased by 10 per cent. from first pay following May 3, 1918.

THE AIR MINISTRY.—The following matter has been circulated by the Secretary to the Air Ministry for general information :—The Air Ministry was established to take over control of the Royal Air Force, which was formed on April 1 by the amalgamation of the R.N.A.S. and R.F.C. The Ministry supplies to the Admiralty and War Office contingents of the Royal Air Force, which, for purposes of operations by sea and in the various theatres of war, are under the supreme naval or military command. There is also an Independent Air Force operating under the Air Ministry. The actual provision of aeroplanes is the responsibility of the Ministry of Munitions. A special group in this Ministry has been set up to meet the needs of the Air Ministry. Departments dealing with technical development, supply, inspection (usually termed the A.I.D.), contracts, finance, &c., all come within this group. The various addresses are as follow : Supply, Contracts and Finance Departments, York House, Kingsway ; Technical Department, Central House, Kingsway ; Inspection Department, Clement's Inn, Strand. Lighter than air craft remain under the Admiralty, the Air Ministry supplying the *personnel* from the Royal Air Force. The responsibility for the defence of London against air raids rests with the War Office, the Air Ministry supplying aircraft and *personnel* for air service in connection with it. In connection with the Air Ministry the following main committees perform the functions indicated : (1) The Advisory Committee for Aeronautics, York House, Kingsway, W.C. 2, is engaged on aeronautical research generally and the investigation of the fundamental problems of flight and the subordinate questions to which it gives rise. (2) The Air Inventions Committee, 2, Clement's Inn, Strand, W.C. 2, investigates all inventions submitted by the public on aeronautical subjects and submits to the Technical Department of the Directorate of Aircraft Production those considered worthy of development. (3) The Accidents Committee, Air Ministry, Strand, W.C. 2, makes special investigation into any accidents which require it.

REACTIVE MAGNESIUM ALLOYS.—In a Note on some Reactive Alloys, presented to the Faraday Society on July 23, by Mr. E. A. Ashcroft, attention is drawn to uses of alloys up to 50 per. cent. magnesium and lead. An alloy with 15 per cent. Mg will rapidly oxidise and turn into a jet-black powder in a damp atmosphere, the powder being a mixture of the hydrates of magnesia and of lead suboxide. The presence of moisture is necessary for the disintegration, but there is no decomposition of water ; on wetting the powders the colour changes to brown and pink. This alloy might be utilised in the laboratory and in small industrial operations for absorbing oxygen and isolating the nitrogen of the atmosphere. Alloys richer in magnesium (35 per cent.) decompose water, but only on boiling, the oxides MgO and Pb_2O and hydrogen being formed ; to hasten the reaction, Mr. Ashcroft works with steam at a pressure of 100 lb. per square inch ; thus hydrogen may be prepared for aircraft and other purposes. The by-products, mixtures of the oxides and hydrates, Mr. Ashcroft regards as valuable reagents, very convenient also for the preparation of lead peroxide and white lead. To obtain the peroxide, the mixture is treated with chlorine ; to produce a very fine white lead, it is treated with carbon dioxide. Mr. Ashcroft is rather optimistic about the value of these by-products and about the method of preparing his alloys and their utilisation. He fuses the two metals together under a cover, or he electrolyses magnesium chloride with the aid of a kathode of fused lead in a new cast-iron cell of his own. The fused lead kathode is not new, of course, but the magnesium chloride to be electrolysed has to be quite free of water, and as this salt is very hygroscopic, that condition is difficult to realise. Mr. Ashcroft has his own patented process for drying the $MgCl_2$, and he draws the alloy of Mg and Pb from his sealed cell, from which chlorine escapes ; the air is excluded. The transport of his alloys in sealed cans, he claims, would be far cheaper than that of nitrogen and hydrogen in steel cylinders, and the apparatus for generating these gases with the aid of his alloys are simple. The alloys might also be used in the recovery of gold from cyanide baths and in organic chemistry. Magnesium-zinc alloys, which he also proposes to produce in his electrolytic cell, fused zinc acting as kathode in this case, are likewise useful as reducing agent and further for pyrotechnic work, as a cheaper substitute for powdered magnesium.

ENGINEERS' PROTECTIVE ASSOCIATIONS.

AT the invitation of the Council of the Institution of Electrical Engineers, a conference of representatives of the Associated Municipal Electrical Engineers of Greater London, the Chief Technical Assistants' Association, and the Electrical Power Engineers' Association was held at the temporary offices of the Institution on the 9th inst. The number of representatives sent by each association was in proportion to its membership. The chair was taken by Mr. C. H. Wordingham, C.B.E., president of the Institution of Electrical Engineers, and the council was further represented by Messrs. R. A. Chattock, G. W. Partridge and Roger T. Smith (vice-presidents) ; and Messrs. A. H. Marshall, R. Howard Fletcher and W. Lang (chairmen of the Newcastle, Western and Yorkshire Local Sections respectively). At the close of the proceedings the following resolutions were passed, subject to ratification by the governing bodies of the three associations :—

1. That one single combined protective association be formed for the whole electric supply industry.

2. That chief engineers be included in the membership provided they are not employers or employers' representatives on an Industrial Council or similar body dealing with technical staffs, subject also to proper safeguards for special staff questions that may arise.

3. That a protective association formed from existing associations adopt the constitution, and for the present, the title of the Electrical Power Engineers' Association, seeing that it is the only existing association for the purposes in view which is constituted as a trade union.

4. That the qualifications for membership of the association be those of the Electrical Power Engineers' Association, but all new members elected after December 31, 1921, shall be required to have passed the A.M.I.E.E. examination, or an equivalent examination, and that this be the link between the Institution and the association.

5. That the Chief Technical Assistants' Association and the Associated Municipal Electrical Engineers of Greater London each appoint two representatives to meet the National Executive Committee of the Electrical Power Engineers' Association at Manchester on July 27, to discuss and approve the draft constitution of the Electrical Power Engineers' Association. This draft, in turn, to be submitted to the Institution for final ratification. The representatives of the two associations first named, if members of the Electrical Power Engineers' Association, to remain as part of the National Executive Committee of the Electrical Power Engineers' Association for the current year (*i.e.*, until June, 1919).

The Institution also to send a representative of the council to attend the meeting of July 27 in an advisory capacity.

SHIPBUILDING ACTIVITY IN DENMARK.—The Elsinore Iron Shipbuilding Company has doubled its capital by the issue of new shares, partly on account of the company being interested in the large new Danish Diesel Motor Company, which is about to commence operations. The Bürmeister & Wain Shipbuilding Company is increasing its area at the Refskale Island, where its shipbuilding industry is located, to the extent of some 11 hectares (27 acres), which will be obtained by embanking and filling up operations on the east side of the island. Negotiations concerning this arrangement with the authorities have been pending for some six years, and yet the firm has not obtained the full area wanted, inasmuch as the plan of removing the machinery shops and the steel works from their old Christianshavn quarters, and also erecting a rolling mill, have had to be abandoned. The company has to complete the embanking and filling up operations in the course of eight years, and to defray all expenses, besides paying a moderate annual rent. As a result of the extension, all the firm's slips, both for building and repairing ships, will face west, towards the Copenhagen harbour, an arrangement which the company considers very desirable. The extension will undoubtedly prove a great boon to the well-known yard, and further enhance its capacity.

LOSSES OF MERCHANT TONNAGE.—The Secretary of the Admiralty makes the following announcement :—The losses of British, allied and neutral merchant tonnage due to enemy action and marine risk during the month of June, 1918, compared with preceding periods are set out below :—

Gross Tonnage.

Period.	British.	Allied and Neutral.	Total.
Second quarter, 1917	1,361,870	875,064	2,236,934
Third quarter, 1917	952,938	541,535	1,494,473
Fourth quarter, 1917	782,889	489,954	1,272,843
First quarter, 1918 ..	697,497	445,318	1,142,815
April, 1918	228,067	85,348	313,415
May, 1918	225,689	131,845	357,534
June, 1918	161,062	114,567	275,629

The tonnage of steamships of 500 gross tons and over entering and clearing United Kingdom ports from and to ports overseas was as under :—

Period.	Gross Tons.
January, 1918	6,336,663
February, 1918	6,326,965
March, 1918	7,295,620
April, 1918	7,040,309
May, 1918	7,777,843
June, 1918	7,430,386

This statement embraces all United Kingdom seaborne traffic other than coastwise and cross-Channel.

NEW CONTINENTAL SHIPYARDS.

THE German Shipyard Company, Hamburg, has now been definitely constituted, and under circumstances which point to its evolving into an undertaking of considerable importance. The company has been formed by the following three large concerns : The Gutehoffnungshütte, the Allgemeine Elektricitäts Gesellschaft, and the Hamburg-America line. The yard will be located at Finkenwärder, Hamburg, the State of Hamburg having placed the necessary area at the company's disposal for a period of seventy years. The share capital, to begin with, has been fixed at the comparatively modest sum of 10,000,000 marks, but it goes without saying that there are virtually unlimited means at the back of the undertaking. Special attention will be paid to the building of vessels driven by internal combustion, crude oil, engines. It is not the first time that the Allgemeine Elektricitäts Gesellschaft and the Hamburg-America line have co-operated, the two companies, jointly with the Hugo Stinnes undertaking, Mülheim, and a couple of other German firms, besides an Austrian syndicate, have thus co-operated in the foundation of the Imperator Motor Works in Berlin, which, so far, are connected with shipping, since the works also manufacture ships' motors.

In Hamburg, a yard of considerable dimensions is being started by A. P. Rickmers, having a share capital of 8,000,000 marks, principally intended for the building of large steamers of a standard type.

A large yard is also to be started in Norway, at Norheim, about 1 mile from Haugesund, under the style of the Karmsund Yard and Dock Company. There will be accommodation for building two vessels of 18,000 tons deadweight, two of 12,000 tons and several of 6,000 tons or less. The conditions are stated to be simply ideal, both as regards the supply of raw materials and in other respects ; there will also be about ½ mile of quay accommodation. The capital, to begin with, will only be 2,000,000 kroner to 3,000,000 kroner, but the new undertaking is supported by a number of leading shipping firms, almost all the founders of the concern being shipowners.

THE BRITISH CHAMBER OF COMMERCE FOR ITALY (INCORPORATED), GENOA.—During the war, this chamber has been actively engaged in facilitating trade relations between Great Britain and Italy. The result has been a correspondingly large increase in the number of members, besides the formation of branches at Rome and Naples, while the establishment of a branch for Sicily is being considered. The membership for 1917 totalled 845. So far, this year, it has increased to about 950.

THE LATE MR. EDMUND HERBERT STEVENSON, M.INST. C.E., F.S.I.—We regret to record the death on July 18 of Mr. Edmund Herbert Stevenson, who was a son of the late Mr. G. W. Stevenson, M.Inst.C.E., and was in partnership with his father for some years at 38, Parliament Street, Westminster. The practice of the firm was largely associated with works of gas and water supply and drainage, and also with private bill legislation in Parliament. Mr. E. H. Stevenson was a member of the Institution of Civil Engineers and was a well-known expert witness in all matters relating to gas or water. He gave evidence in the recent Gas Bills this Session, although his fatal illness had at the time begun to assert itself. In 1890 Mr. E. K. Burstal, M.Inst.C.E., M.I.M.E., joined partnership with Mr. Stevenson, and the firm as Stevenson and Burstal carried on the practice at 38, Parliament-street, for nearly 20 years, when Mr. Burstal retired, and Mr. Stevenson associated his brother Mr. S. E. Stevenson with him. Mr. E. H. Stevenson was joint author with Mr. Burstal of "Precedents in Private Bill Legislation affecting Gas and Water Undertakings," "Considerations Affecting the Adequacy and Control of the Water Supply to the Metropolis," &c., and of a paper read before the Inst. C.E. on the "Sewage of Douglas, Isle of Man," which the firm had designed and completed. Mr. Stevenson was 65 years of age at the time of his death. He married a daughter of Sir Titus Salt, Bart., and leaves one daughter.

HYDRO-ELECTRIC POWER FROM THE DRAVE RIVER, STYRIA, AUSTRIA.—The Electricity Works Faal, on the Drave, in Southern Styria, were opened last May. The works are the property of the Electricity Works of Graz, the capital of Styria, the financial arrangements were in the hands of the Swiss Railway Bank in Basle, and the contracts were taken over by the Austrian Baugesellschaft für Verkehrs und Kraftanlagen of Vienna. The war has delayed the operations which were started in 1913. At present the turbines can supply 30,000 h.p. ; but the plant is to be enlarged. The Drave is an Alpine river which joins the Save, one of the main tributaries of the Danube. About 15 km. above the town of Marburg the Drave has been closed by a dam which raises the water-level by from 11 m. to 15 m. ; this dam has five openings, and the power station is close to the dam and in the longitudinal axis of the river. Shipping and rafting are maintained on a canal which branches off the right bank and is provided with two locks, 7 m. wide and 31 m. long. So far, five turbines with horizontal axes, each for 6,000 h.p., have been installed in the power-house, but there is room for two larger turbines, each of 8,000 h.p. The turbines are directly coupled with three-phase generators giving currents of 10,000 volts. The electrochemical works of the district are directly supplied with these currents ; for the long-distance power transmission the tension is raised to 80,000 volts, the transformers being installed in a separate building adjoining the power-house.

METALLURGICAL ELECTRIC FURNACES.

THOUGH the late Sir William Siemens experimented with his electric crucible furnace forty years ago, the real development of the electric smelting furnace pertains to this century, and the actual commanding position of the metallurgical furnace in this country is very largely due to the war. When the Faraday Society held a general discussion on "Electric Furnaces" last February, at the Municipal School of Technology, Manchester, under the presidency of Professor C. A. Edwards, D.Sc., the chairman stated in his introductory remarks that, while there had only been four electric-smelting furnaces in operation in Europe and America up to 1904, the number had risen to 114 by 1913, and the development had been phenomenal since. The statistics are uncertain, chiefly because many furnaces always remain in the experimental stage; but the recent astounding development is unquestionable. The discussion by the Faraday Society was not limited to metallurgical furnaces; we will deal particularly with iron and steel furnaces, however. A striking feature of the discussion was the general criticism of the Kjellin induction furnace; it was an ingenious invention, but it is not a furnace for large capacity, and the wide area of contact between the metal and the narrow annular trough is an undesirable feature. Yet we notice that the first electric-steel furnace, built in South Africa last year, is of the Kjellin type. At the Witwatersrand, some 7,500 tons of steel are wanted annually for the stamp-battery shoes and dies, especially for gold milling, and when that supply failed, we see from papers by Messrs. G. H. Stanley and W. Buchanan, in the "Journal of the Chemical, Metallurgical and Mining Society of South Africa," a committee decided to adopt an induction furnace. It has hardly been a success; it was not anticipated that scrap would be the chief direct raw material available, for which the Kjellin furnace is little suited, and there have been complaints about the variation in the carbon percentages and breakages of the shanks. The difficulties may partly be due to inexperience of the men in charge. But it was generally acknowledged at the Manchester meeting mentioned, that there is great need for improvement still in the engineering design of steel furnaces, especially with regard to the construction of the doors, of the openings for the electrodes, and of the silica roofs, the enormous strain put on the refractory materials, and the operation of the furnaces. Against these drawbacks of the electric furnace stand the possibility of working under adjustable thermal and chemical conditions in oxidising and reducing atmospheres, and the purity of the product. We begin our notice of the proceedings with an abstract of the most general contribution to the discussion.

Fig.1. ALTERATION OF TRANSFORMER RATIO BY MEANS OF TAPPINGS.

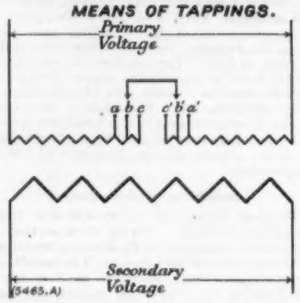


Fig.2. ALTERATION OF TRANSFORMER RATIO BY MEANS OF AUXILIARY WINDING.

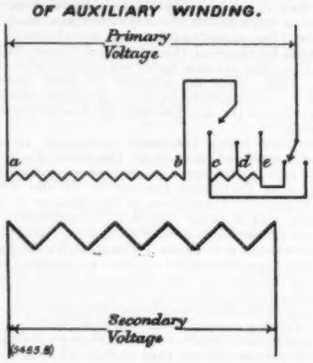


Fig.3. VARIATION OF VOLTAGE BY MEANS OF PRIMARY BOOSTER TRANSFORMER.

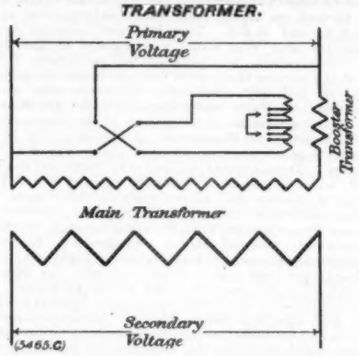


Fig.4. VARIATION OF VOLTAGE BY MEANS OF SECONDARY BOOSTER TRANSFORMER.

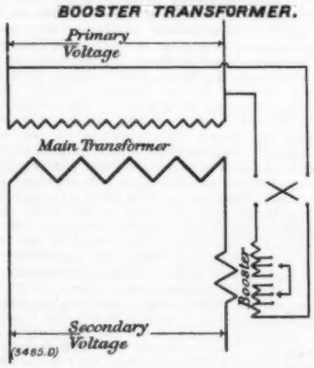
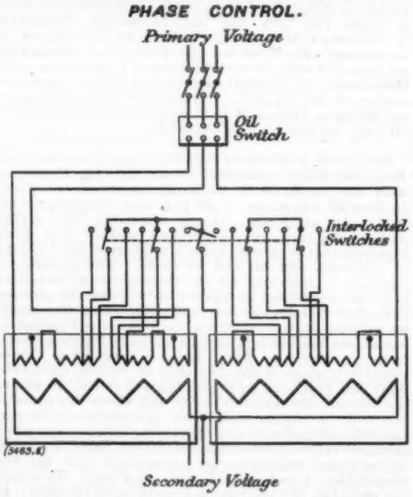


Fig.5. ARRANGEMENT OF TAPPINGS AND SWITCHES FOR THREE TO TWO PHASE CONTROL.



ELECTRIC STEEL-REFINING FURNACES.

The discourse by Mr. J. Bibby, M.Sc., of Electro-Metals, Limited, London, dealt with the general features of the problems, partly on popular lines. Electricity, as such, he pointed out, played no part in steel making, and precautions were, indeed, taken to prevent any electric action. The effect was thermal, and the heat might be generated by resistance or by the arc. To make the metal itself the resister seemed to be the natural way, and great efforts in that direction had been made on the Continent. But in the induction furnace the metal was in a ring trough, in contact with large surfaces of refractory material, low-tension currents had to be used, the reactance was high, and the power factor, hence, low; the iron was hot and the slag cold, and the furnace awkward for slagging and fettling. Arc heating was, therefore, preferred, and 95 per cent. of the steel furnaces were now of the arc type. The electrodes might be above the bath (Héroult), or both above and below (Girod and Electro-Metals); Girod's water-cooled lower electrodes projected through the hearth, the hot hearth of Electro-Metals conducted the current to an electrode below. The arc heat could be distributed by conduction and by circulation. The conduction downward in the bath being slow, circulation could be provided by rocking the furnace, which was inconvenient, or by putting the bath in the condition of the rotor of an electric motor with a horizontal axis. With two upper electrodes and one below, the bath would, on an alternate-current system, be situated in a rotating magnetic field, which would carry the hot metal from the arcs down to the bottom; that was especially advantageous also in the manufacture of iron alloys with heavy metals, such as tungsten, as it helped to dissolve the tungsten. The rotating magnetic field required at least two upper electrodes and one lower. When the current travelled down one upper electrode, it entered the metal through an arc, passed along the surface layer of the metal and then through another arc up to the other electrode; the circuit between the two upper electrodes comprised two arcs, whilst the circuit between an upper electrode and the lower comprised only one arc and the comparatively small resistance of the bath; the system was hence, not balanced. For that reason, it was not admissible to join, on three-phase circuits, the three phases directly to the three electrodes. In the two-phase system, each phase was joined to one upper electrode, and the third electrode served as common return. As, however, most supply companies worked on the three-phase system, a static Scott transformer was used to convert the three-phase into two-phase working. The current through the common neutral return was then $\sqrt{2}$ that of one-phase.

Mr. Bibby then described the construction of a tilting furnace of Electro-Metals. The rammed-down hearth consisted of dolomite and tar, a layer of carbon mixture was placed over this, and flat copper plates were imbedded in this layer, with their ends projecting through slots in the sides. The drying of the furnace could be effected, though not economically, by charging it with coke, keeping the doors closed to exclude the air, and inserting the upper electrodes into the coke. Furnaces of up to 5 tons' capacity would work with two upper electrodes. The large steel furnaces, which were preferred to small types, required more than two upper electrodes, as these could not carry more than 10,000 amperes each without becoming unwieldy, and it was best to have four upper electrodes above the bath for four phases, with a common return through the one lower electrode, a five-wire system. The four phases could be obtained by working two sets of two phases in parallel; but the new arrangement of Electro-Metals for converting three-phase into four-phase supply was electrically superior, and did not require selector switches. In this arrangement the three primaries of three single-phase transformers were connected in star; two of these transformers were main transformers, and their secondary terminals were separately joined to the four upper electrodes. The secondary of the third transformer, a teaser, was tapped in its middle by a connection with the neutral hearth electrode, whilst each terminal of the teaser was connected with an intermediate point on one of the main secondaries. A closed system was established when arcs were struck between each of the four upper electrodes and the neutral electrode. With the aid of a vector diagram, Mr. Bibby showed that the resulting low-tension system was very simple, so that, equal voltages being impressed upon each upper electrode and the hearth, four equal currents and four equal heating zones were obtained. Their 20-ton furnace formed a rectangular tank with a charging door on each side, and a teeming spout in front; the furnace was circular in section; it was mounted on rockers and tilted by means of an electrically-driven screw gear. At the back of the furnace, fixed to the main tank, were the standards upon which the electrode-carriages travelled, the carriages being operated by a screw inside each standard; a collar at the outer end of the carriage gripped the electrode. The roof consisted of silica or bauxite bricks, the basic hearth of dolomite and tar. The flexible packing glands of Electro-Metals round each electrode on the top of the furnace retained the gases and prevented oxidation of the electrodes; constructive details of these features were not dealt with.

We pass to a paper by Messrs. Frank E. Hill and A. P. M. Fleming, of the British Westinghouse Company, Manchester, setting forth the general principles of the control of furnace temperatures.

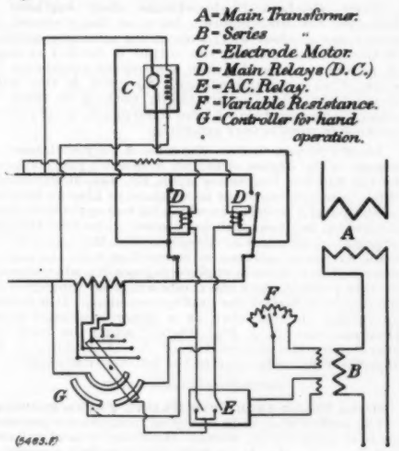
CONTROL OF ELECTRIC FURNACES.

Confining themselves to furnaces supplied from alternating-current sources, Messrs. Hill and Fleming pointed out that the voltage was applied to the

electrodes in contact with or within striking distance of the charge, and the supply should, therefore, suffice to strike and to maintain the arc, and to produce the required temperature. For this purpose, the pressure might vary from 40 to 130 volts. The principal methods of control were: (A) by variation of the voltage; (B) by variation of the current. In case (A), the variation was effected: (1) by altering the ratio of the main transformer either by tappings, or (2) by an auxiliary winding; (3) by the use of a primary booster transformer, or (4) of a secondary booster transformer; (5) by means of a motor-generator. In case (B), the electrodes could be operated: (1) by hand; (2) by electric or hydraulic power under manual control; (3) by an automatically-controlled motor.

(A) *Voltage Control.*—(1) The voltage per turn of a transformer being practically the same in the primary and the secondary windings, the secondary volts would increase, when a portion of the primary was cut out, while the primary pressure was kept constant. Thus, when, in Fig. 1, the connection between c and c_1 was altered so as to connect up $b\,b_1$ or $a\,a_1$, the volts between the secondary terminals would be raised. If

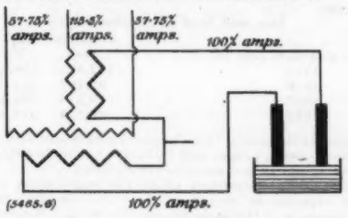
Fig. 6. RELAY TYPE OF REGULATOR.



the primary had 308 turns, the secondary 2 turns, and there were 15 turns between tappings a b and a_1 b_1, and 21 turns between b c and b_1 c_1 on a primary circuit of 10,000 volts, the secondary volts would, for connections aa_1, bb_1, cc_1 be 85, 75, 65 respectively. A. (2).—In Fig. 2, the main primary winding was ab, the auxiliary portion being between c and e. The auxiliary winding could be coupled in series to the main winding, and the number of turns thus added to the primary be varied by the tappings indicated on the diagram; the volts across the secondary terminals would then be reduced in a like ratio. Conversely, the auxiliary and main winding could be connected in opposition so that part of the primary was neutralised, and the volts per turn of the primary were raised. In the case of Fig. 2, five different secondary voltages might be obtained with one tapping in the auxiliary. In case A. (3) (Fig. 3), the main transformer ratio was kept constant, and the secondary voltages were varied by altering the pressure supplied to the primary winding by means of a booster transformer; the secondary winding of this booster was permanently in series, to the primary of the main transformer, the primary of the booster being connected across the supply circuit. Tappings were provided in this winding, and by the aid of a reversing switch, the booster could raise or lower the volts supplied to the primary. Case A. (4) (Fig. 4), secondary booster transformer, was similar to A. (3), but the secondary of the booster was in series with the secondary of the main transformer; the primary winding of the booster being now connected across the supply circuit through a reversing switch. Method A. (5), control by a motor generator, was rarely used where central supply was available, as it required a special motor-generator set for each furnace; the pressure supply to the primary of the transformer was varied by adjusting the field current of the generator.

In comparing the various methods of voltage control A., attention had to be paid (*a*) to reliability, and (*b*) to cost. (*a*) Reliability depended principally on the ability of the windings to stand voltage surges and displacements due to the mechanical forces set up by the rapid load fluctuations. During switching operations, the potential was concentrated between the adjacent turns near the ends of the windings connected to the primary circuit, and unless great care were taken there was weakening of the insulation at the points where the tappings were brought out; when these were placed on the terminal portions of the primary windings, very high voltages might momentarily occur between adjacent terminals during switching. For this reason the tappings were brought out at the centre portion of the primary, as indicated in Figs. 1, 3, 4, though that arrangement was more expensive than with tappings from the ends of the primary. When the secondary windings consisted of coils in parallel sandwiched with the primary windings, each portion of the primary should have its turns changed symmetrically, lest the reactance of the secondary circuits should vary, and wasteful currents circulate between them. With respect to (*b*) cost, in ordinary transformer service the volts per turn were practically maintained constant. The magnetic inductance was likewise constant at all loads, and the magnetic circuit could hence be designed with the maximum induction that temperature and performance would permit. In furnace transformers, when the volts per turn were altered, materials of the the magnetic circuit could only be worked with the greatest economy when the volts per turn had the maximum value; that condition involved the use of a certain number of idle turns, as Fig. 1 clearly showed.

Fig. 7. DIAGRAM ILLUSTRATING THE RELATIVE LOADING IN THE DIFFERENT PHASES OF A THREE TO TWO PHASE TRANSFORMER ARRANGEMENT DURING STARTING CONDITIONS.



Further, when the load conditions were such that the secondary current varied, the windings should obviously be designed for the maximum current loading; the copper would not always be economically loaded, the most economical use of the copper requiring a secondary current constant at all voltages.

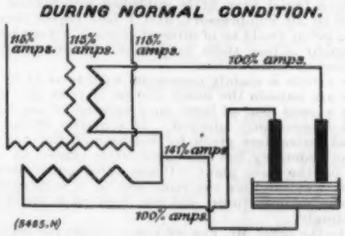
Regulating Switches.—The alterations of the connections were accomplished either by the aid of a system of individual switches, interlocked so as to prevent their being operated when the main switch was opened, or by a dial switch or a drum controller. Fig. 5, showing the arrangement of a three-two phase supply, illustrated the former method. When the voltage was to be varied without breaking the circuit by a switch bridging two adjacent tappings, a "preventive resistance" was inserted to avoid a short circuit during operation; these resistances were not essential with boosters, where the main circuit was not interrupted in any case, but were still preferable. Finer regulation was obtained with the aid of an induction regulator (to operate between tappings), which was virtually an induction motor. When the stator winding was excited as the primary of a transformer, the voltage induced in the secondary of the rotor varied according to the relative positions of the two windings. By moving the rotor through an arc, the volts across its terminals were varied, up or down; the rotor winding, being in series to the primary of the main transformer, was automatically cut out as the operating switches moved from tapping to tapping.

B.—*Current Variations. Regulators.*—The input into the furnace could be varied by raising or lowering the electrodes, and this method could be used either in the place of the A. methods, or as an auxiliary to them. Moving the electrode was employed principally in steel furnaces; in the United States, furnaces for the production of calcium carbide and abrasives were frequently controlled in that way likewise. The regulation might be by a hand-operated winch; for large furnaces hydraulic power or electric motors were resorted to. The Thury regulator was a successful type of regulator for this control. In the Thury regulator a constant-speed motor caused a lever to oscillate about a fixed centre. A second lever was balanced at the one end by a spring, and at the other by the repulsion of a solenoid, energised from the secondary of a series transformer inserted in the furnace leads; as the second lever tilted up or down under the action of the solenoid, it engaged with the first lever, a pawl on which caused a ratchet wheel to rotate in a direction, corresponding to the furnace current variation; thus a relay was operated and the motors were controlled, which raised or lowered the electrodes. In the Routin relay type of regulator, much used in America (Fig. 6), the armature of a shunt-wound motor C was coupled in series with two main interlocked relays D controlling the current direction; the D relays were excited from a third auxiliary relay E, which was operated through a series transformer B inserted in the secondary of the main furnace transformer A; relay E was in a neutral position when the current to the furnace was at a predetermined value; in order to set the relay to this predetermined value, the series transformer was provided with a secondary auxiliary winding short-circuited through the variable resistance F.

Furnace Current Condition.—The loads fluctuated very much; as, further, the secondary currents were heavy, and the distance between the transformer secondary terminals and the furnace electrodes might be considerable, the resistance of the low-tension leads might become high, in spite of their being split and interleaved. This was an advantage in so far as it limited the rush of current to the electrodes when the electrodes were practically short-circuited. Where, however, the reactance of the leads was kept low, that of the transformer windings was purposely increased; sometimes a separate reactance in the secondary circuit was used by preference to a high internal reactance in the main transformer.

In this country it was common practice to operate

Fig. 8. DIAGRAM ILLUSTRATING THE RELATIVE LOADING IN THE DIFFERENT PHASES OF A THREE TO TWO PHASE TRANSFORMER ARRANGEMENT DURING NORMAL CONDITION.



furnaces from a two-phase to three-phase supply. The current relations prevailing during the starting period—before the furnace bed reached the conducting state, when the current was flowing only from electrode to electrode—were illustrated in Fig. 7; during this period there was considerable out of balance in the three-phase supply, but matters readjusted themselves to uniform primary loading when the furnace was working under normal conditions, as Fig. 8 indicated.

(*To be continued.*)

A GERMAN SALVAGE OPERATION.—Last year a German steamer sank outside Kalmar, Sweden, having first been aground, and as the vessel ultimately broke her back, any salvage operations were abandoned at the time. The salvage company Neptun, however, has since succeeded in raising the aft portion of the vessel, which was conveyed to the Oxelösund yard, where a new fore part was added to the salvaged aft portion. The vessel, which is of 500 tons, has now been added to the Halmstad fleet.

RUSSIAN FOREST INDUSTRY.—In 1916, a company was formed in Denmark under the style of the Foreign Forest Industry Company, with a capital of 8,000,000 kronen. At the same time, the Russian Forest Industry Company was started in Christiania, with a capital also of 8,000,000 kroner. The Danish company owns a total of 60 forests covering an area of some 130,000 hectares (321,260 acres), situated about 250 miles east of Petrograd, and the Norwegian company likewise possesses vast expanses of forests in Russia. Some anxiety has been caused, more especially in Norway, by the Bolshevik Government threatening to confiscate all forests, but in Denmark no serious apprehensions are felt on that account, and the company's work in Russia proceeds as usual.

MINERAL RESOURCES OF GREAT BRITAIN.—The Board of Agriculture and Fisheries desire to give notice of the publication of the Sixth Volume of the Special Reports on the Mineral Resources of Great Britain, which have been prepared by the Director of the Geological Survey in response to numerous inquiries that have arisen through the conditions brought about by the war. This volume constitutes the first of a series which will deal with the refractory materials of Great Britain. The greater part of it is concerned with the sources of ganister and silica rocks used in the manufacture of silica bricks, or suitable for that purpose. The occurrences of these rocks are described in detail, and an account is given of their geological relationships with brief notes on their petrological characters and the methods employed in their treatment for the market. The quarries and mines are described under the names of the firms operating them, arranged according to counties or grouped in districts. Copies may be obtained, at the price of 7*s.* 6*d.* net, through any bookseller from Messrs. T. Fisher Unwin, Limited, 1, Adelphi-terrace, London, W.C. 1, or from the Director-General, Ordnance Survey Office, Southampton.

SCIENTIFIC CONTROL OF BOILER PLANT.

TO THE EDITOR OF ENGINEERING.

SIR,—The information given by Mr. Brownlie is so interesting as to cause regret on reading the word "concluded." Many readers must have wished for more details, especially in tabulated form, concerning the individual performances of plants from which he obtained his averages. Having been guilty of installing too many economisers in a plant and of feeling proud of such excess and of the increased "saving" caused by extra investment in induced fan draught, I can fully appreciate his remarks on economisers; but find difficulty in following him on the subject of draught. All measurements of pressure are liable to be vitiated by Venturi effects, and it would be of great value to many if Mr. Brownlie would tell us how he obtained reliable results in measuring the pressure at foot of chimney where great velocity occurs, as wide variations may be caused by a change in the shape or position of the end of the pipe which is connected to the gauge.

Yours, &c.,
EDWARD C. BARTON.

TESTING AIR COMPRESSORS.

TO THE EDITOR OF ENGINEERING.

SIR,—I notice that your correspondent, Mr. Fairley, does not consider the tests of a 4,000-cub. ft. compressor at full and no-load to have been worth the making, as the results are much the same as would be obtained from any good make of compressor.

I have found very little published information with regard to air compressors, and I had hoped that the figures given would be of interest to some of your readers and might induce them to publish the test results of machines of other makes.

The article is mainly concerned with tests at no-load which are outside the usual routine of tests and which throw a good deal of light on a method of air control which is commonly adopted. As a matter of fact, the no-load guarantees given by Belliss and Morcom were very considerably less than guarantees offered by other firms for the same plant. If any other good maker of compressors can give the same results, it is remarkable that the manufacturers did not base their guarantees accordingly.

As to the point Mr. Fairley makes about the supposed unfair advantage obtained by determining the volumetric efficiency at half-speed, my experience is that a pump-up test at half-speed is no advantage to the compressor. The volumetric efficiency is, if anything, lower, as the slip past the air valves is greater at the lower speed, and any surging effect at the inlet tending to increase the output, decreases with the speed.

In the present instance tests were taken at both full and half-speed and found to agree very closely, the result being 4,129 cub. ft. at full speed and 4,112 cub. ft. at half-speed. The power is, of course, measured at full speed and load. The air calculated from the cards was somewhat in excess of that shown by the pump-up tests.

I can assure Mr. Fairley that every care was taken to ensure the accuracy of the results.

Yours faithfully,
N. S. TENNANT.

38, Grainger-street West, Newcastle-on-Tyne,
July 24, 1918.

SWEDISH AEROPLANE SERVICE.—The furtherance of aeroplane service in Sweden has been taken up by a number of influential persons and concerns. With the view of forming a syndicate, in which the three largest banks in Sweden will be interested, a committee has been formed under the most promising auspices. M. Knut-Wallenberg, the large financier and formerly Swedish Foreign Minister, takes a leading part in the proceedings, and the large shipowner, M. Boström, has also promised his support; unlimited capital is stated to be available.

NEW NORWEGIAN INDUSTRIES.—A recent exhibition in Christiania illustrating Norwegian industrial self-help, shows that an extensive work has been undertaken to make Norway more independent of foreign supplies. A factory for the making of crucibles, based on artificial graphite from the Arendal Smelting Company, will soon commence operations at Langesund. Ferro-manganese was formerly imported, but is now made at the Fiskaa works. Several concerns having taken up the manufacture of electrodes, of which 8,000 tons were formerly imported per annum. The requisite quantity of sulphate of aluminium, some 4,000 tons per year, is now being manufactured within the country; chloride of lime and soda lye, glue and various dye-stuffs; red lead, &c., will be manufactured on a basis which will leave some for export, after the country's requirements have been met; iodine, which formerly it did not pay to manufacture on account of the powerful iodine Trust which the war has broken, will now be made on a scale large enough to supply all Scandinavia. A Holmestrand concern has worked out new methods for the production of bismuth and various preparations from it. Nitro-cellulose and collodion cotton, which were formerly manufactured from imported cotton, are now being made from ordinary cellulose, which seems to yield a suitable product. Formerly Norway imported her entire requirements of grinding materials, especially from America, Germany and Austria-Hungary; now these requirements are being entirely covered by home manufacture. The exhibition also comprised electric lamps, porcelain articles for electro-technical purposes, material for the complete equipment of electric installations, electric cables, &c.

IMPORTS AND EXPORTS.

IT is sometimes contended that imports, other than raw material, are a trade loss, and all exports a trade gain. In these times a different view must be taken. Imports are a needful and welcome supply; exports are mainly a proof that we can help our Allies. From this point of view the returns for the first half of this year are decidedly reassuring. In the great essential materials we are able to send substantial supplies to our Allies, and at the same time overcome the effects of an enormous decrease in our imported supplies.

The following tables deal with two groups of steel products in the stages nearest to what may be called raw material steel.

Steel Ingots, Bloome, Billets and Slabs.

First half year of—	Imports. Tons.	Exports. Tons.
1913	293,565	2,180
1916	20,322	44,039
1917	23,703	72,438
1918	10,392	43,202

No statistics of home production are available, but we may safely infer from the above figures and the known general facts that home production is able (1) to meet an increased demand, (2) to make good a loss of supply of 280,000 tons and to spare 40,000 tons for our Allies over and above our 1913 exports. Of course, all the figures are for the first half of the years noted, to make them comparable with the latest returns for this year.

Plates, bars, rods, angles and various sections are the next forms of most general use, and a similar comparison shows the same tendency, though in a less marked degree.

Iron and Steel Plates and Sections.

Fist half-year of—	Imports. Tons.	Exports. Tons.
1913	302,325	358,894
1916	92,122	694,005
1917	49,379	364,355
1918	28,754	213,851

In this table tinned or galvanised plates and also beams, girders, joists, pillars and rails, are not included. Ship-building plates and sections are included.

The general tendency of all the engineering imports and exports, in so far as they are essential for war purposes, is of the same favourable kind. Weights only are considered because prices are too much disturbed to be easily comparable and are also very largely artificial and not market prices. The two tables may be reduced to the following ratios of weights of steel:—

	Imports.	Exports.
1913	100	100
1918	7	71

This shows a substantial net gain in our independence of foreign production.

ANTIMONY SULPHIDE IN PRIMERS.—Antimony sulphide is a common constituent of most primers, though authorities differ as to the function it is to perform in the primer. Two kinds of primers may be distinguished: Detonators, consisting essentially of percussive explosives like mercury fulminate or lead azide; and rapidly-burning powders consisting of a fuel, sulphur or carbon, and an oxidising agent like chlorate of potassium. The antimony sulphide is to support the reactions while mitigating them; the hard grains of the needle crystals which are used are further intended, it is said, to produce friction (powdered glass serves for the same purpose), to keep the reacting materials apart and to act as catalyst. The sulphide must, of course, not impair the properties of the primer, particularly not its stability on storing, and for these reasons a high purity of the sulphide is generally insisted upon, *e.g.*, in Marshall "Explosives" of 1917. The antimony, it is demanded, must be free of sulphuric acid, of sulphides of lead and iron, and of arsenic and must, on treatment with *aqua regia*, not leave more than 0·5 per cent. of insoluble residue. When the war interfered with the supply of antimony sulphide which the United States mainly imported from China and Japan, although the mineral occurs in their own country, Dr. Allerton S. Cushman—now lieutenant-colonel in the Ordnance Department—investigated the necessity of the high purity demanded, and arrived at the conclusion that most of the dreaded impurities are harmless, and that the supply specifications are unnecessarily rigorous. The natural antimony sulphide Sb_2S_3 occurs as stibnite, mostly in quartz, and is gained by heating the ore, the stibnite melting at 555 deg. C. During this operation some oxidation is unavoidable, and it was considered necessary to extract this oxide by means of tartaric acid. Cushman finds this purification unjustifiable, if not actually dangerous; a few per cent. of oxygen in the "needle antimony"—the common name for the antimony sulphide crystals of grey-blue metallic lustre actually used—do not deteriorate the sulphide at all. Nor does the silica (up to 5 per cent.) which on analysis is left behind as insoluble residue; gritty silica (from the gangue)-may injure the machinery, but otherwise acts merely as a diluent. The sulphides of lead and iron are not objectionable either, in small quantities; in fact, they can be substituted with advantage for antimony sulphide in primers, though further tests will have to be made as to the stability of such primers. Cushman, who performed also ballistic tests (*Journal of Industrial and Engineering Chemistry*, pages 376 to 386, May, 1918) during his exhaustive study, in fact expresses the opinion that statements as to the requirements of the antimony sulphide have passed from one text-book into another, as frequently happens, without being put to the test, and that the use of this compound has been handicapped by senseless limitations.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—In contradistinction to the many ultra busy weeks which preceded it, the past has been a completely idle one so far as actual steel output has been concerned, although a considerable amount of overhauling and repair work to machinery and plant stands to the credit of the men employed on this very necessitous duty, which can be undertaken only at holiday times. Work is never too promptly resumed, after the annual recess, but in this connection there is little to complain of this year, and a very few days will see every man and every woman hard at it once again. Very commendable indeed have been the efforts of the gangs of engineers and bricklayers entrusted with the repair work to get all in readiness for a speedy resumption of activities, for unquestionably events on the Western Front will make heavy demands on the steelmakers' resources. Strengthened and refreshed, however, by their rest and holiday, the workers will be able to go at the task set them with renewed vigour, and without doubt a further increased output will be the consequent result.

Malleable Iron Trade.—The malleable iron workers having been on holiday there is practically no news of any account whatsoever and, naturally, a day or two must elapse before all the mills are in full swing again.

Scotch Pig-Iron Trade.—Unlike their brethren in industry, the iron smelters have, so far, pursued the even tenor of their way, and, under present conditions of Government control, the output is divided as fairly as possible among the most necessitous consumers for work of national importance. So great is this home demand that there is practically nothing to spare for export, a regrettable fact from some points of view as the advance in price is very tempting.

Lloyd's Surveyor's New Honour.—A very well deserved honour is the degree of Doctor of Science just conferred by the London University upon Mr. Jas. Montgomerie, B.Sc., principal surveyor in Scotland of Lloyd's Register of Shipping, a position to which he was appointed on its institution last year, previous to which he held the post of principal surveyor in Glasgow. Mr. Montgomerie has made extensive research in connection with the laws of flexure of flat plates of engineering quality when exposed to fluid pressure, and the thesis which he submitted for the degree embodied the results arrived at. It is further interesting to note that, in a paper entitled "Stress Determination in a Flat Plate," which he read last year before the Institution of Naval Architects, Mr. Montgomerie made some of the information public.

SILICA BRICKS FROM OPEN-HEARTH FURNACE ARCHES.—The arches of open-hearth steel furnaces are generally made of silica bricks, whether the lining be acid or basic; and these silica bricks undergo some profound modification in service owing to the action of the heat, gases and dust. Examining a considerable number of bricks taken from various furnaces, E. Rengade (*Comptes Rendus*, May 13, 1918) finds that, starting from the lower portion of the arch, four zones may be distinguished: A. The portion which is in immediate contact with the flames looks varnished and shows frequently stalactitic excrescences which indicate pasty fusion; the fracture is light grey, suggesting a homogeneous mass, which may, however contain blow-holes. Above A, and generally separated from it by a sharp line, is a dark grey or black zone B, also very homogeneous apparently, and of great hardness. In zone C, further above, white patches appear and the colour changes into a dark brown; higher up the original brick structure can again be distinguished. In zone D, in the top of the arch, finally the original bricks have remained unaltered. The polariscope shows in B big, highly transparent crystals of tridymite (a modification of quartz), cemented by a black material. In A the same crystals seem to have fused into spherules which the black coating has kept separate; the fused cooled tridymite has partly passed into cristobalite. In the C zone the crystals of tridymite diminish more and more in size and number. The chemical analyses show that, starting from 97·5 per cent. of silica in the original brick (D zone), the silica percentage decreases in A and B, to 88 per cent. and even to 75 per cent., and that the iron percentage, originally 0·43 per cent. or 1·2 per cent. (as Fe_2O_3), *e.g.*, may go up to 10 per cent. and even 20 per cent., especially in the B zone; most of this iron, which must come from the spray or dust of the furnace, is in the oxide condition, but there may also be 5 per cent. of the protoxide FeO. The black coatings are most likely iron, of course, but the iron percentage does not decide the colour, which depends rather on the transparency of the crystals; thus the confused mass of small grains in A appears less dark than the big transparent crystals of B. The fusibility of the bricks is not much influenced by the iron oxide contents, an observation which agrees with others. On the other hand the lime, of which the original brick contained about 1·4 per cent., seems to fuse and to rise in the arch by capillary attraction, up to 3·5 per cent. of lime being found in zone C. That the melting-point of silica is not much lowered by the presence of iron oxide, unless alkali be also present, is also shown by some experiments made by Bied and described in the same number of the *Comptes Rendus*. These experiments are not very convincing, however; the general conclusion is drawn, that an addition to a quartz of 3 per cent. of iron oxide and of 1 per cent. of lime, does not lower the melting-point of silica (about 1,725 deg. C.) by more than 5 deg. C., but one does not quite see on what evidence it is based. More figures are given to show that the mixture swells on calcining when there is no vitrification, but does not swell when vitrification takes place.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Small Tools Order.—During the past week there has been a development in connection with the Order, issued some time ago, by the Ministry of Munitions, prohibiting the manufacture of small tools without a licence. From the commencement, manufacturers have objected to work under the Order, and now, as the result of representations which have been made to the authorities, the Order has been suspended, pending the formation of an Advisory Committee representing the makers, to deal with the matter.

Industry and Influenza.—The influenza epidemic has, so far as the industrial community is concerned, practically played itself out, and employment is now the same as it was at the beginning of the month, before the malady had made its appearance.

Iron and Steel.—Conditions are still marked by a quiet tendency, but an acceleration is likely at any moment. Government calls for steel have fallen to a comparatively low level. The open-hearth steel furnaces are being fully employed, and in the steel foundries and forges too there is a degree of briskness apparent. In the crucible and electric steel departments, however, matters are very quiet, and the rolling mills, too, are not being very heavily taxed. Operations in the iron foundries have been interrupted. There is an increasing demand for hand tools, &c., from the engineering and shipbuilding trades, but the scarcity of labour is retarding output.

South Yorkshire Coal Trade.—Trade undergoes no variation. Best steam hards are in strong demand, the whole of the output being divided between railway companies, iron and steel works and exports to France and Italy. Supplies of cobbles, nuts and slacks are short, and consumers are being caused anxiety by their depleted stocks. Slacks are particularly difficult to obtain. The demand for house and gas coal continues very strong, and in advance of the supply. Cokes are difficult to obtain. Quotations:—Best branch hand-picked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

SWEDISH STATE AEROPLANES.—A special commission which has been investigating the aeroplane problem with a view to a reorganisation of the service has handed in a report, recommending some radical changes and extensions entailing a material outlay of 33,000,000 kronor for the army and 11,000,000 kronor for the navy, during respectively five and three years.

A FUEL ECONOMY UNION IN DENMARK.—After about a year's preparatory labours by a committee appointed for the purpose, the Danish Fuel and Control Union has now been formed, with a highly representative board, in which various leading industries, agriculture, &c., are represented. The work of the new Union is divided into three sections: manufacturing industries, agriculture and central heating installations. A number of tests have already been undertaken, at the Polxtechnic High School, and the large Carlsberg breweries, Copenhagen. The Ministry of the Interior has requested the Union to take up experiments with the view of utilising Danish fuel, more especially in the cement industry, so that the cement works can be kept going, and thus reduce the existing unemployment of an increasing number of hands.

NORWEGIAN SHIPPING.—It is stated that the Norwegian Government has entered into a contract with a Norwegian shipbuilder who is about to start a yard on the Mexican Gulf, in the vicinity of Mobile, Alabama, for the building of 19 good-sized vessels, to the total amount of about 30,000,000 dols. The contract is stated to be the largest so far concluded by the Norwegian Government with any Norwegian-American. For the first time during several years the balance of the Norwegian merchant navy for May is on the right side. The losses amount to 25 vessels, having an aggregate tonnage of 17,800 tons, whilst the additions consist of 23 new vessels having an aggregate of 19,217 tons, the satisfactory total being due to the Stavangerfjord, 13,000 tons, the new vessel of the Norwegian-America line. The Norwegian merchant navy now comprises 3,263 vessels having an aggregate tonnage of 1,952,000 tons.

GERMAN SYNDICATE FOR COAL CHEMISTRY.—At the general meeting of the Goldschmidt Company, Essen, which pays a dividend of 12 per cent. for last year, the same as for the preceding year, it was stated that the company, jointly with the General Board of the Prince Henckel von Donnersmarck property and the firm of Robert Friedlander, Berlin, had started a "Syndicate for Coal Chemistry," with a capital of 30,000,000 marks. This syndicate will work the patents for coal exploitation and benzene production, and take over the Rheinau works. The business of the syndicate will be conducted by the Petroleum Exploitation Company, of which all shares are held by the syndicate. The Goldschmidt Company had acquired all the shares in the company for petroleum industry and had thus the entire control of the patents and installations. The board found it necessary again to warn against excessive expectations, and stated that the present high exchange of the company's shares was not warranted. It was further stated that new processes, especially when the scope is a wide one, require both much time and a heavy outlay.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Opinion prevails that quotations of Cleveland pig-iron for home consumption will not follow last week's rise in export prices, but that the situation will be adjusted by subsidy. An advance in home prices would have a far-reaching and embarrassing effect, and it appears to be generally agreed that to settle the question by subsidy is preferable to raising prices. Deliveries of pig-iron are large, and show some improvement due to abatement of the influenza epidemic and consequent better conditions as regards labour. The labour shortage, however, is still an obstacle to distribution. Iron is urgently needed, especially for the Clyde foundries where work is now in full swing after the holidays. Output of foundry iron falls considerably short of what could be wished, but production of forge quality continues heavy. The latter is still plentiful, and makers are pressing sales on both early and forward account, notwithstanding the fact that substantial contracts have recently been made. There are no new developments in the export trade. Shipments are well maintained, and tonnage is rather more plentiful. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge all stand at 95*s.*, and No. 1 is 99*s.*; whilst for shipment to the Allies, No. 3 and the lower qualities are 119*s.* and No. 1 124*s.*

Hematite Iron.—Supply of East Coast hematite is maintained, but with heavy demand unabated, make is promptly absorbed by the home trade, and relatively little surplus iron is available for shipment abroad. Continued careful distribution under strict official control, however, enables home consumers to obtain regular and adequate supplies for their essential needs. Mixed Nos. remain at 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for export to the Allies.

Manufactured Iron and Steel.—The labour shortage is creating some difficulty in the manufactured iron and steel industry, but on the whole output is well upheld, and hopes of further increased production by works extensions are entertained. With the system of controlled distribution working smoothly, customers with first call on available supplies are assured of adequate deliveries. Prices are very still, but unaltered. The following are among the principal market quotations:—Common iron bars, 13*l.* 17*s.* 6*d.*; best bars, 14*l.* 5*s.*; best best bars, 14*l.* 12*s.* 6*d.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel hoops, 17*l.* 10*s.*; and heavy steel rails, 10*l.* 17*s.* 6*d.* Though export quotations are not fixed, they may be given at approximately 2*l.* to 3*l.* above home prices.

Coke.—The huge demand for coke cannot be anything like satisfied. Scarcely any neutral trade is passing, but one transaction has occurred in foundry quality at the extraordinarily high price of 65*s.* Gas coke, for shipment, is in the neighbourhood of 40*s.* Home consumption of all classes of coke is heavy. Only with difficulty are the minimum essential needs of the blast furnaces met. Medium furnace coke is 33*s.* at the ovens, and quality low in phosphorus 35*s.* 6*d.* at the ovens.

Shipyard Extensions.—Plans for extensions to workshops at Sir Raylton Dixon and Co.'s, Limited, Cleveland Dockyard, Middlesbrough, were this week approved by the Plans Committee of the Middlesbrough Corporation.

GERMANY'S SHORTAGE OF METALS.—A number of German monuments are now sharing the fate of the church bells, many of them being melted down for war purposes. The Germans, however, comfort themselves with the thought that other countries have had to adopt similar measures in past times, and that there are plenty of ugly and inartistic monuments in Germany which can very well be spared.

DISCOLORATION OF WHITE PAINT.—Zinc-white "enamels" frequently turn yellow and brownish, especially in warm atmospheres, both in the light and dark. In some cases this discoloration is merely a staining of the paint with atmospheric dust and dirt. In others it is not without reason attributed to the presence in the pigment or oil of traces of lead. Studying the question, Dr. D. F. Twiss (*Journal of the Soc. of Chemical Industry*, June 29, 1918) found that lead cannot be responsible in all cases, since the discoloration sometimes proceeds in the absence of all sulphuretted hydrogen and is not accelerated by its presence. The linseed oil and varnish themselves slowly tend to turn brown when absorbed by dry filter paper and kept for a few hours at 60 deg. C., and the brown colour appeared quite as readily when this experiment was performed in sealed tubes charged with pure carbon dioxide, as under ordinary conditions; thus the presence of oxygen and the action of high temperature, which would polymerise the oil, are not at all essential, contrary to expectation. On the other hand it proved possible to bleach the brown tint again by the light rays from a quartz-mercury lamp; for this reaction, however, the presence of oxygen is necessary, as was expected, the real bleaching agent being probably the ozone. Dr. Twiss was able to repeat the discoloration and bleaching experiments several times with the same specimens. The effects might also be due to the presence of manganese or of alkalis; but the experiment in carbon dioxide is against the latter assumption, and even if radio-activity should be concerned in the phenomena, which is not unlikely, the colour change would ultimately be the manifestation of a chemical change in the pigment or medium.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—The market has been featureless. The shortage in supply continues and the authorities are commandeering practically all the coal that is reaching port. In many cases the percentage of smalls shipped in cargoes is much above the average, and as the proportion of the outputs now being lifted by the Admiralty is greater than ever the delay of the naval authorities in settling the price question is felt more acutely. The supply of pitwood is good and the arrivals of iron cargoes are stated to be well up to the average.

Newport.—All classes of Monmouthshire coals continue short, and little business is taking place, other than that under the direct control of the authorities. There is little or no coal being released on private account, and deliveries are in arrears in almost every direction.

Speeding-up Coal Transport.—Details regarding the appointment of a committee at Cardiff to deal with the transport of coal in the Bristol Channel ports were officially published to-day. Its proper title is the Bristol Channel Shipping and Coal Co-ordinating Committee, and its functions are to arrange with the District Coal and Coke Supplies Committee a shipping and coal programme week by week, and decide all questions of priority as regards destination under instructions of the Admiralty, Ministry of Shipping, Controller of Coal Mines, and the Coal Export Committee. The need for such a committee is generally admitted, but on the South Wales coal markets to-day the chief criticism directed against it was that it was not representative enough on its commercial side, and that its operations were likely to be hindered, if not harassed by the multiplicity of the authorities with power to direct its work.

GAS PRESSURES IN CARBONATED WATER.—Very little experimental work has been done on the actual gas pressures resulting when carbon dioxide is forced into water, and when the carbonated water is afterwards stored in bottles or siphons. According to Henry's law, the concentration of a gas dissolved in a liquid is proportional to the pressure of the gas at the given temperature. This law is known to hold when the molecular condition of the solute (the gas) is the same in the gaseous and the dissolved states respectively; it does not hold for substances which polymerise or dissociate electrolytically when dissolved in the fluid. In the case of carbondioxide, the law can hardly be expected to apply strictly, considering that the CO_2 probably combines with the water, although the hydrate of the carbonic acid anhydride (which is the carbon dioxide CO_2) is not known. The recent experiments of A. E. Patten and G. H. Mains, of the United States Bureau of Agriculture (*Journal of Industrial and Engineering Chemistry*, April 1918, pages 279 to 288), show, however, that the law of Henry is fairly applicable when CO_2 is forced into distilled water at the relatively high pressures of 4 atmospheres or 5 atmospheres. But they also show that pressure determinations made under siphon conditions, when the gas is occasionally blown off, may be misleading, owing to a peculiar influence of the residual gas (air) left in the water and in the gas cushion above the water, and this point is of general interest. The experiments are made by impregnating distilled water with CO_2 by the aid of a rotating stirrer at 0 deg. C., and at pressures up to 70 lb. per sq. in. The gas pressure in the bottle is subsequently determined after opening the bottle for a moment, so as to let the free gas escape; the valve is immediately closed again, the process is repeated, and the rise of pressure is watched, time observations being also taken; plotting pressures against time (in minutes) as abscissa, "pressure-recovery" curves, were obtained, which were strikingly regular on the whole. In the final tests, the gas is withdrawn at higher temperatures, ultimately by boiling, to be analysed; but in the ordinary recovery determinations, the temperature was kept at freezing point. After the first blow-off, the pressure rose, *e.g.*, to 9 lb. per sq. in. in 5 minutes, to 16 lb. in 10 minutes, to 21 lb. in 86 minutes, to 30·5 lb. in 1,140 minutes; the original stirring pressure being 65 lb. With the second opening (blow-off), that pressure of 30·5 lb. dropped down to 0 lb. again, then to rise to 31 lb. in 253 minutes; after the ninth opening, a pressure of 27·5 lb. was restored in 1,140 minutes; after the final seventeenth opening, the recovery up to 22 lb. took 25 minutes. The curve following the first opening was the least regular, but the pressure recovery was always rapid at first, becoming very slow after about 10 minutes. With high-speed stirring (2,000 revs. per minute), high original pressures were easily obtained. The recovery depends, as mentioned, on the partial pressures of the CO_2 and of the other gas, in this case, the residual air and the nitrogen contained in CO_2 used in the experiments. This gas would partly collect above the liquid and escape during the first blow-off and the subsequent openings. During this opening, bubbles of gas form on the bottle walls, serving as nuclei for the liberation of more gas; with short periods between the openings, this liberation is rapid. When sufficient time is allowed, on the other hand, equilibrium will be reached between the pressure of the gas and vapour cushion above the liquid and the gas pressure in the liquid; if the bottle be re-opened before that equilibrium is established, the upper vapour layers will not be at their full concentration, and the recovery will therefore be retarded. For these reasons, the initial pressure, *i.e.*, the pressure of the gas cushion indicated on a gauge connected to a bottle of the carbonated liquid before opening the bottle, is not really an indicator of the gas-content of the liquid, and the curve of the initial partial pressure of the CO_2 and the saturation curve are not identical.

THE NEW FURNESS SHIPYARD ON THE NORTH-EAST COAST.

(*For Description, see Page* 82.)

FIG. 1. GENERAL VIEW OF SITE.

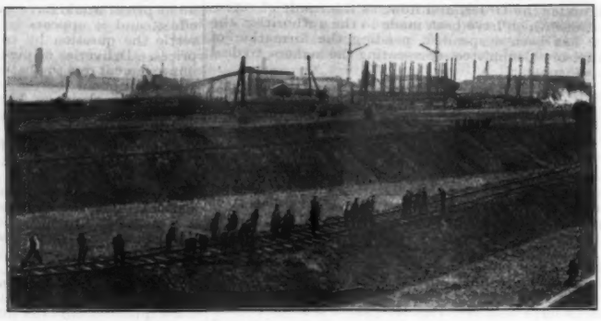


FIG. 2. TRACKS FOR BALLAST TRAINS.

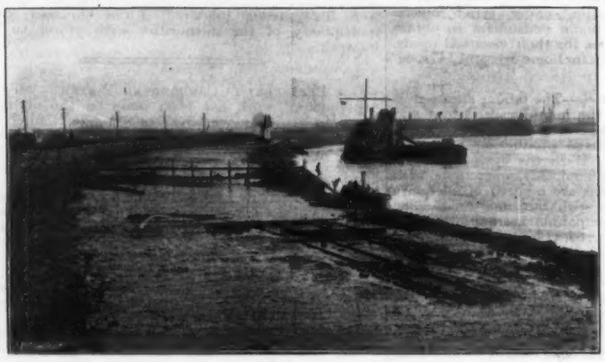


FIG. 3. EMBANKMENT AND FORESHORE.

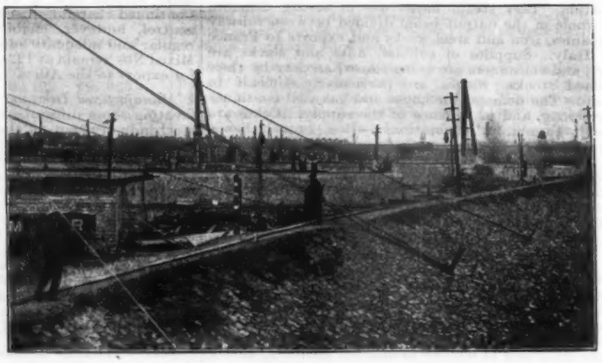


FIG. 4. BERTHS BEHIND EMBANKMENT.

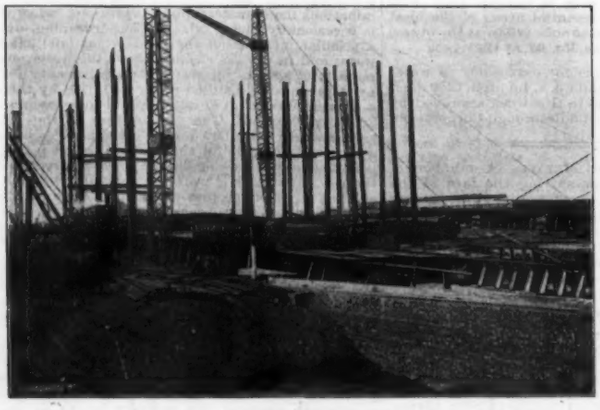


FIG. 5. BERTHS AND SHIPBUILDING CRANES.

FIG. 6. THE KEEL OF THE SECOND VESSEL.

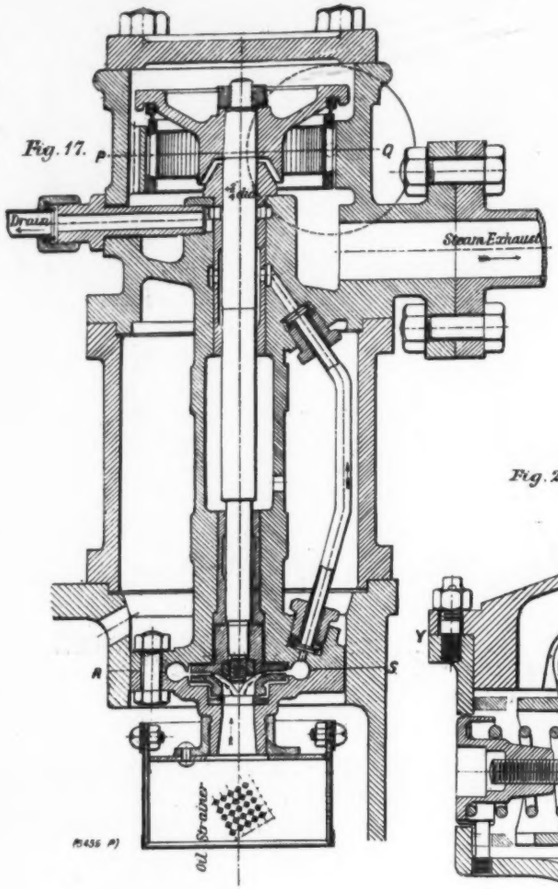
FIG. 7. WOMEN CHARGING CONCRETE MIXER.

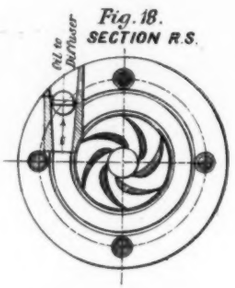
FIG. 8. WOMEN BALLASTING RAILWAYS.

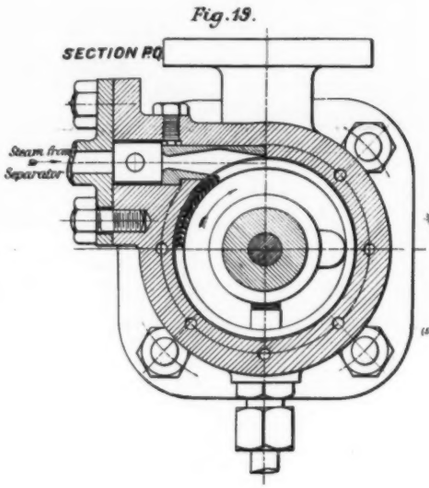
LJUNGSTRÖM RADIAL-FLOW STEAM TURBINE FOR S.S. "WULSTY CASTLE."

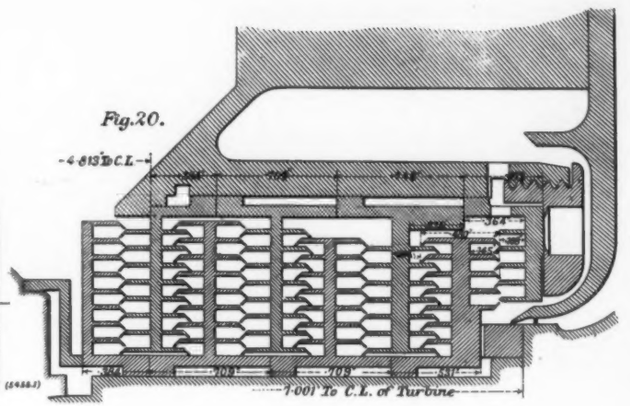
CONSTRUCTED BY THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, LOUGHBOROUGH.

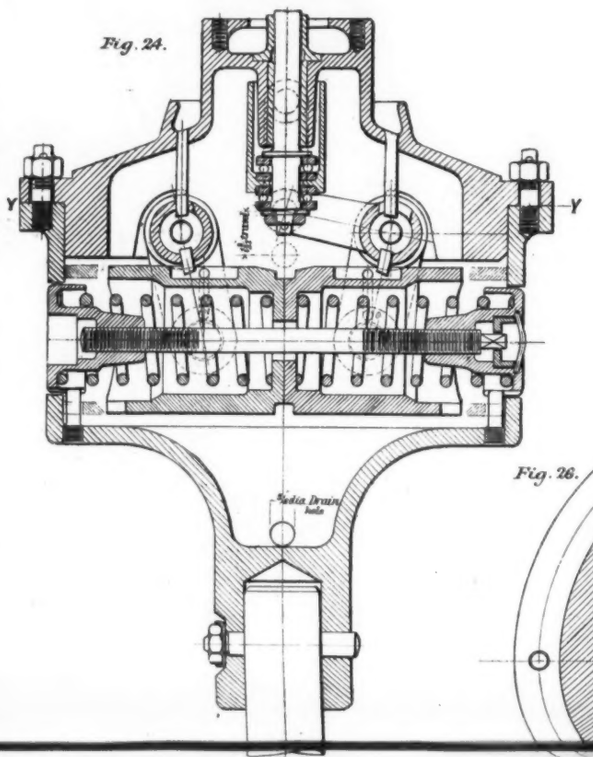
(For Description, see Page 82.)

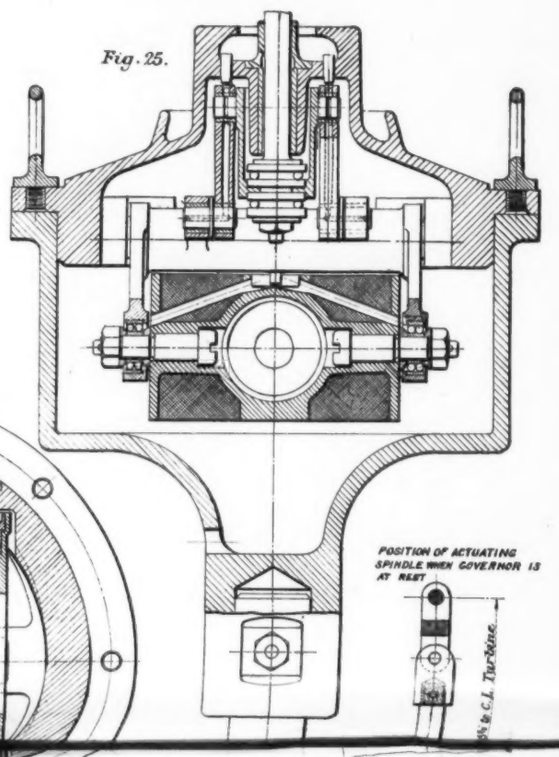


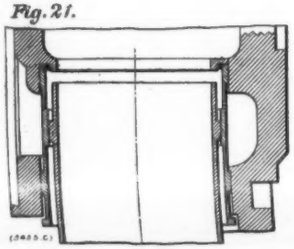


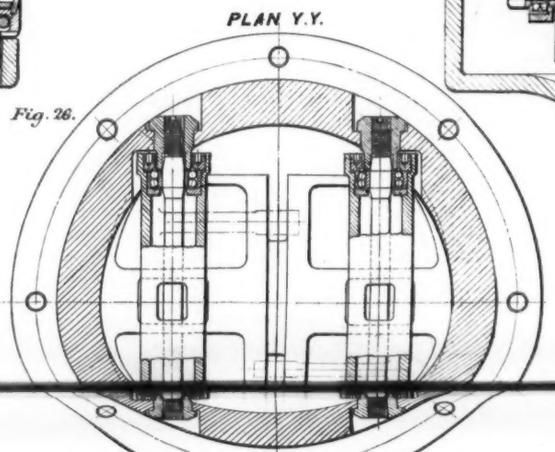


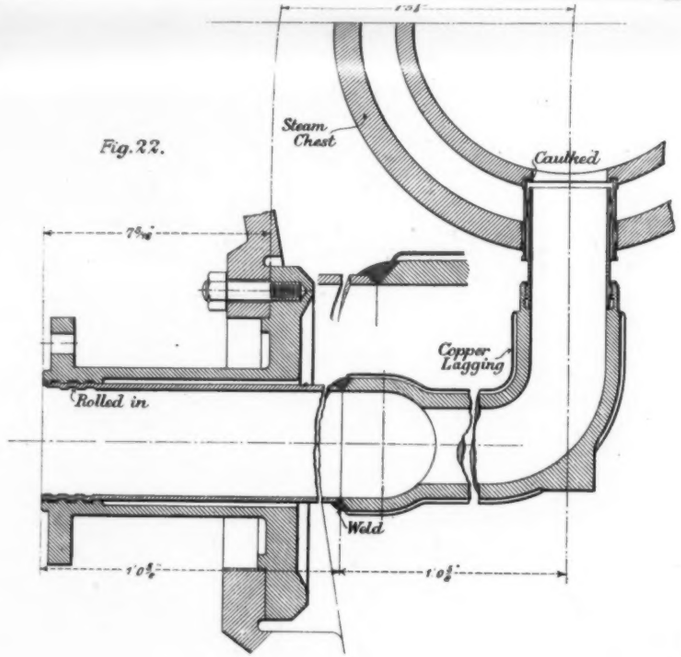












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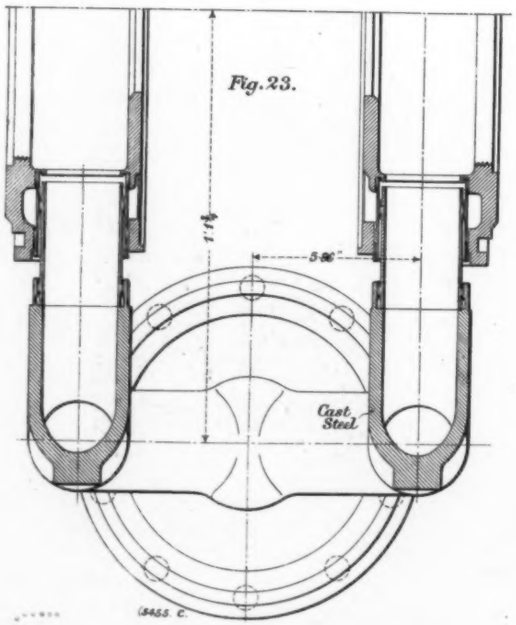

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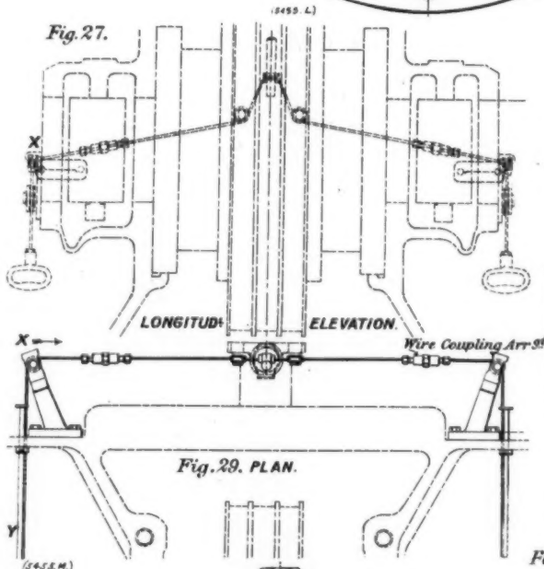
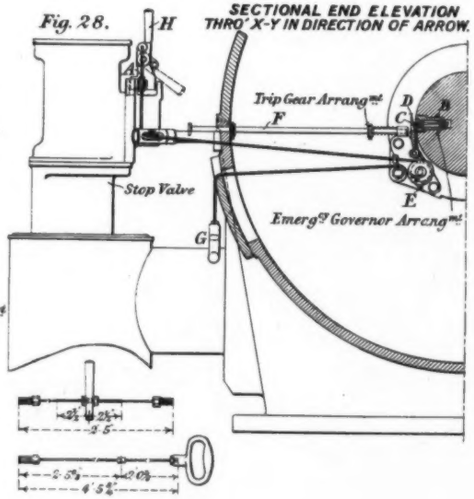


Fig. 27.

Fig. 29.



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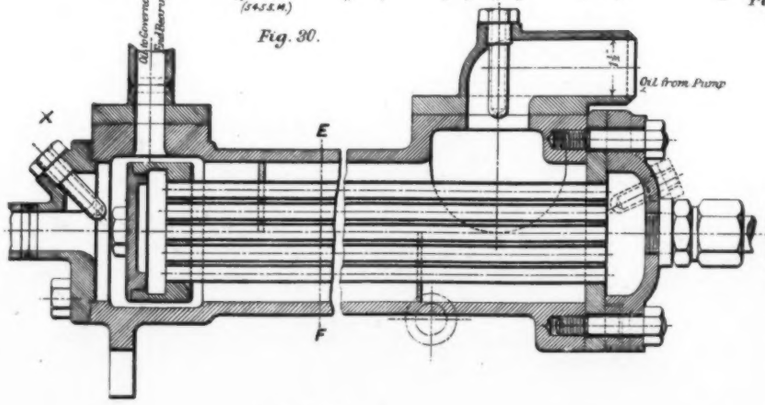

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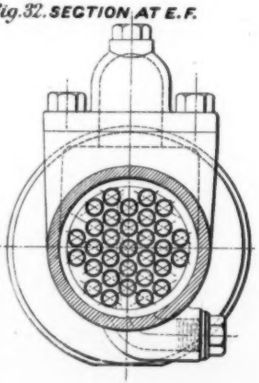

Fig. 32. SECTION AT E.F.

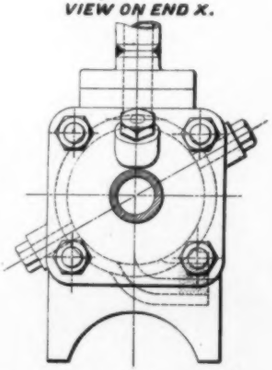

Fig. 33. VIEW ON END X.

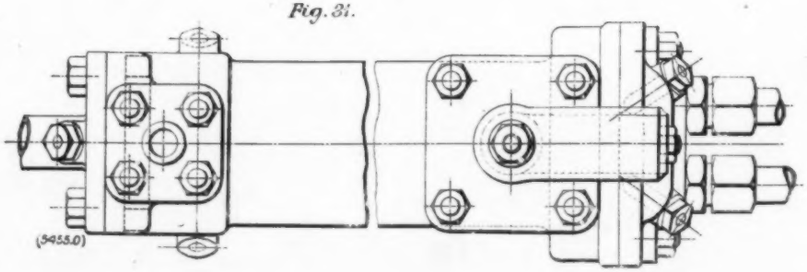

Fig. 31.

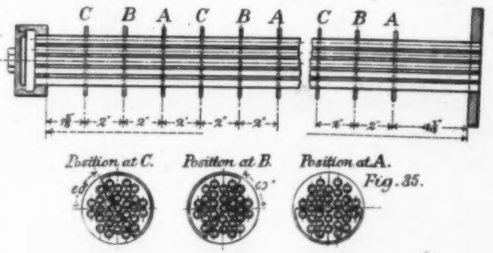

Fig. 34.

Fig. 35.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

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TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3065 and 8596 GERRARD.

CONTENTS.

	PAGE		PAGE
The Salt Trade in the United States (*Illus.*) ...	77	Notes from Cleveland and the Northern Counties...	89
Templets, Jigs and Fixtures.—No. IX (*Illus.*) ...	79	Notes from the South-West ...	89
The Ljungström Turbo-Electric System of Ship Propulsion (*Illus.*) ...	82	The New Industrial Era ...	91
A New Furness Shipyard (*Illus.*) ...	82	British Engineering Enterprise and Chinese Railways ...	92
Industrial Notes ...	84	The Boquilla Hydro-Electric Power Plant in Mexico ...	93
Engineers' Protective Associations ...	85	The National Physical Laboratory in 1917-18 ...	94
New Continental Shipyards ...	85	Notes ...	96
Metallurgical Electric Furnaces (*Illus.*) ...	86	Literature ...	97
Scientific Control of Boiler Plant ...	88	Steel Staging for Shipbuilding Berths (*Illus.*)...	98
Testing Air Compressors ...	88	The Effect of Cold-Working on the Elastic Properties of Steel (*Illus.*)...	99
Imports and Exports ...	88	ENGINEERING Patent Record (*Illus.*) ...	106
Notes from the North ...	88		
Notes from South Yorkshire...	89		

With a Two-Page Plate of the LJUNGSTRÖM RADIAL-FLOW STEAM TURBINE FOR S.S. "WULSTY CASTLE."

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents after June 24th will not have copies for chance customers, therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

ENGINEERING.

FRIDAY, JULY 26, 1918.

THE NEW INDUSTRIAL ERA.

THE present industrial situation is fraught with great interest to the thoughtful engineer, who finds speculations as to the future arising in his mind as each new aspect of the subject presents itself to his eye. Nearly every prominent man has given public utterance to his thoughts, and while many of the current views are conflicting, certain ideas are crystallising out for final consideration. Not every pronouncement *ex cathedra* by men of reputation helps matters, but the lengthy discussion is developing a trend whose direction is worth attention. While many of the ideas appear irreconcilable, this aspect is to some extent superficial, although many employers, realising that change is imminent, make the most of the irreconcilability without formulating any alternatives.

First comes the claim by the workmen to increased leisure either by shortening the working day to an ultimate six hours, or shortening the week to five days. Second is a demand for the permanency of higher general wages, which inevitably rest upon a subsistence standard. Third is the increasing political pressure exercised by labour, which is likely to prove cumulative in its effects. The electoral register has been greatly extended recently, and it is difficult to see at the moment exactly what the newly enfranchised electors in bulk will desire. In practical directions, such as the control of sweated industries, arbitration in disputes, fair wages clauses and other steps to the advantage of labour, definite practical work of praiseworthy character has been done in industry.

Fourth is the great problem as to how the vast burdens imposed by the war can be liquidated, as they must inevitably be in a solvent State, mainly by industrial profits.

Fifth is the question as to restriction and limitation imposed by trade societies, either directly or by influence, on the members. The promise as to restoration of conditions may be impossible to keep in a literal and accurate form.

Sixth come the basic underlying economic factors that even legislation is powerless to alter or restrict and which inevitably, since they are universal and not national in character, have to be taken into due account. Historical precedents have been ransacked in a futile attempt to assess present conditions, financial authorities are perplexed at the high scale upon which operations have to be conducted, economic experts are giving the gravest attention to the ultimate outcome whereby the centre of gravity of human effort is being slowly transferred.

The troubles are those of a period of acute change profoundly affecting the evolution of the State at every point where it makes contacts with the individual. To prescribe remedies or to attempt to reconcile the conflicting elements in so huge a change may well seem hopeless. The views of the patriot, the workman, the employer and the community at large are diverse, yet by some sacrifice all round and patient endeavour a new poise and balance may be found.

International competitive trade rivalry has to be faced; the wastage of war restored; the enfranchisement of adults in a general sense requires a true scale of political values, not the exploitation of ignorance by the sharpwitted demagogue; increased leisure and a higher standard of comfort to all are demanded; and means having been found to cheapen production and so increase industrial wealth, it is useless to pretend any longer these do not exist. It must be admitted that there was, not so long ago, too great a proportion of the population idle, and this at both ends of the scale. No one should be ashamed to earn his own subsistence by personal effort irrespective of possessions, individual credit or economic independence. Every individual has wants, great or small, which he endeavours to supply, and it is a poor commentary upon national organisation if there is not an overplus for retention, that is if each does produce more than he consumes. It is out of this margin that capital is evolved and taxation paid. The excess of wages beyond bare subsistence meets the needs of individual wants other than necessities, and in a rightly constituted State no one works for the simple means only to keep body and soul together. Such a margin is useless or is pure waste unless the individual has time in which to spend his surplus with deliberation. Shorter hours and higher wages are both possibilities dependent upon an increased production sufficient to offset both, and in the proper enterprise and organisation of industry, education is necessary to management equally with the man to ensure that the results shall be a maximum.

To obtain the desired end there must be a term put to restriction of effort, shorter hours and increased wage can only be afforded if in the time and at the price the result is justified. Where long hours and low wages prevail, energy being proportional not to time worked but being virtually an equal quantity, the results will inevitably be meagre, the means employed be primitive and the profits strictly in ratio. Where, on the other hand, high wages or short hours or both are worked, there is an abiding incentive to employ the worker economically by aiding him with every device that ingenuity can suggest. The justification for the machine is that it multiplies men, and the aid of mechanism should ultimately set man free from bondage and all the worst features of toil.

Primarily the wastage of war must be made good, so that for a while, at all events, we must resign ourselves to the inevitable, in that the new order which is within human compass must be deferred. We may parcel out the day's toil as follows: One hour will go to pay for the cost of the war, one hour for the direct interest of the industry itself, profit, overhead expense, renewals and inevitable wastage, four hours for subsistence and two for the means of leisure. The proportions may be wrong, but the idea is sound.

For war purposes a vast reservoir of unutilised labour has been tapped; thousands are working to provide for their own wants who hitherto were an unproductive burden. It will be folly to scrap this potentiality to resume the incidence of the burden on fewer shoulders.

We have learned to limit our wants, and before hostilities end we may have to cut our necessities to a bare minimum. In other words, the practice of economy will not be optional, it will be by necessity. With the restoration of normal conditions the practice of limitation will still need to persist, and the claims of the nation will limit every purse.

Curiously enough, few producers see their purchasing power as hours of labour, although they are paid by time. It is certain that a gradual emancipation will come, the financing necessary to-day is a draft on potential future credit, and as the burden gets lighter conditions will be improved.

Finally, to gain what each and all desire, leisure and comfort in a free and democratic State, the greatest relative number of producers is necessary, real unrestricted effort of every industrial unit, genuine co-operation between management and man—whose real interests are identical, not opposed—the more intensive application of mechanism to industry, of improved methods everywhere; will serve not merely to liquidate an immense burden but to (in course of time) enable every industrial unit to have a rational life with some provision against contingencies.

BRITISH ENGINEERING ENTERPRISE AND CHINESE RAILWAYS.

WITH the very serious question of employment after the war for the great war-born industries in front of us, a summary of our various engineering interests in China and a consideration of the possibility of their future extension is very desirable, as it is evident that we should make arrangements for utilising to the full every market open to us. As regards China, Great Britain's chief engineering interest lies in the Chinese Government railways built with British money, engineered by and still partially managed by us. In the present article, therefore, we propose to confine our remarks to this branch of engineering enterprise, leaving other branches to be dealt with on a future occasion. The open lines of railway in China run by us are as follow :—

Railway.	Length, miles.	Amount of Loan.	Date.	Date of expiry.
*Peking-Mukden ..	607	£2,300,000	1898	1944
Shanghai-Nanking (Southern Section)	203	£2,900,000	1903	1953
Tientsin-Pukow ..	237	£2,960,000	1908	1938
Canton-Kowloon ..	89	£1,500,000	1907	1937
Shanghai-Ningpo ..	214	£1,500,000	1908	1938

* Loan for Extra-rural Extension only.

In addition to those named in this table the following railways are, or were, under construction with British capital :—

Railway.	Length, miles.	Amount of Loan.	Date.	Date of expiry.
Canton-Hankow ..	430	£3,000,000	1911	1951
Pu-Hsin	290	£3,000,000	1913	1953

Of the above, only the Canton–Hankow railway has been able to keep going on half its length, and that with many delays owing to difficulties in obtaining railway material of any sort and to the disorganisation resulting from the very frequent disturbances in the region traversed by the railway. In any case the British manufacturer has not been able to compete for supplies, most of the material coming from America, the only possible source of supply under the circumstances. About 200 miles of the line have been completed and opened for traffic. With regard to the Pu–Hsin Railway, the loan was not floated at the outbreak of the war, and nothing has been done beyond the survey and a few miles of earthwork. Lack of funds stopped all work early in 1916.

It should be stated here that the amount given above as the loan for the Canton–Hankow is only an estimated proportion of the Four-Nation Group Loan of 6,000,000*l.* for the construction of the Hukuang Railways. Our interest in the Canton–Hankow Railway is therefore shared by America, Germany and France, but as the chief engineer of this line is bound by the agreement to be British, our influence on this undertaking may be said to predominate.

The following are also British concessions in which with the exception of the Nanking-Hunan line, nothing has been arranged but the preliminary agreement. In the case of the line just named a chief engineer has been appointed, and a considerable amount of survey work done, but all work has been stopped since 1916 :—

Railway.	Length, miles.	Loan.
Nanking-Hunan	640	£8,000,000
Shasi-Singyi	760	
Chinchou-Chaoyang ..	80	

The conditions under which the Shasi Singyi Railway is to be built are a new departure for China, the line being built by Pauling and Co. on a percentage of the cost basis, and pledged to them as security.

British interests are also concerned in the China–Burma Railway project, a concession for which was applied for in 1898 by the Yunnan Railway Company. But for reasons probably connected with the financial stringency which followed the South African War this project was not pushed at the time and has never been revived since. There is also one purely British railway in China, the British section of the Canton–Kowloon Railway, which has a length of 22 miles all in the Colony of Hong Kong.

The British investor is also very largely interested in 12,000,000*l.* 5 per cent. debentures issued in London by the South Manchuria Railway Company, and also in the Anglo-French loan of 5,000,000*l.* for the redemption of the Belgian loan for the construction of the Kin-han Railway. Thus if British railway interests in China are summarised it will be found that we partially manage 1,350 miles of railway in which British capital to the extent of 11,100,000*l.* has been invested, that 720 miles of railway is under construction under British management for which some 6,000,000*l.* has to be raised, and that we hold other concessions for the construction of a further 1,490 miles of railway.

It should also be observed that all these railways with the single exception of the Peking–Mukden Railway in North China lie in the so-called British sphere of influence, the Yangtse River Valley. The isolation of this line is to be regretted, and it would appear that every effort should be made by our Government to obtain control of the Northern Section of the Tientsin–Pukow Railway, until lately in German hands, but under Chinese management since China went to war with Germany. British control of the whole of the Tientsin Pukow Railway is not only the obvious thing since we have always managed the southern section of 230 miles, but it would also effect a considerable economy both by eliminating the duplicate staffs which obtained before the war, and by doing away with the German methods of exploitation and management which have proved so very expensive in the past. Moreover, the Chinese Government would be within its rights in adopting this policy as they may by the loan agreement appoint one foreign chief engineer for the whole line. It should also be remembered that Russian and French opposition to the connection of the Peking-Mukden Railway with our lines in the Yangtse Valley, which was responsible in 1897 for the loss of our control of the Peking–Hankow Railway after 100 miles had actually been constructed under British management, no longer exists, and that the Japanese, who now presumably control Shantung, have no real grounds for opposition.

A discussion of the terms under which we have lent this 11,000,000*l.* of money for railway construction is perhaps not out of place here, as it is a moot point whether these terms might not be improved to the mutual benefit of both nations. The interest on the loans, which has always been 5 per cent., is secured by mortgaging either the railway itself or the revenues of the district traversed. Also all British loan agreements stipulate for a British chief engineer and accountant, and have also a clause allowing repayment of the loan after a term of years varying from twenty-five to forty-five, at par, or if payment is desired before this, then it is to be made at a certain premium, varying from 20 per cent. in the case of the Peking–Mukden Railway to 2½ per cent. in most of the later loans. In addition, most of the later agreements do not allow repayment before the lapse of ten or twelve years in any case. Also all agreements except the Peking–Mukden Railway allow a commission of 5 per cent. during construction to the loan syndicate, on all purchases and also stipulate that preference shall be given to British manufactures provided there is no great difference in the open market cost.

These clauses would appear at first sight to be of a sufficiently protective nature and to assure that a market in China shall be kept open for our manufactures. That the market is kept open, results from the presence of British engineers after the line is opened, but owing to the fact that the policy of the line after its construction is controlled by the Chinese Government this market does not develop as it ought to, and we consequently do not obtain full value for the money invested. This is a consideration which will be of vital importance after the war when we must either divert our enormous war industries to the supply of new markets or incur colossal loss. The extraction of the very utmost from our investments is therefore really a vital necessity.

As things are now, on completion of a railway it is handed over to a department of the Chinese Government called the Board of Communications, the foreign staff, or a proportion of them, being retained. This Board is under a Minister of the Chinese Government and, under its absolute control, directs the policy of all the Government railways, telegraphs, roads, &c. It had, previous to the war, four foreign advisers, one German and one French on railways, a Dane for telegraphs, and an American for railway accounts. The absence of the British element is remarkable when it is recalled that British capital has built rather more than one-fifth of China's total railway mileage, and that we have lent far more money for this purpose than any other nation. The powers of these foreign advisers, however, are very limited indeed owing to the frequent changes in the Constitution of the Government and to the fact that no Ministry in China has any permanent officials. Efficiency of management is thus impossible and would be impossible in any country.

Resignation of a minister thus means, as a general rule, a clean sweep of all his underlings by his successor, with the inevitable consequence that the management of the most important Government department is frequently being carried on by men new to their work. Moreover, these men are unsettled because they take office with a full knowledge of the fact that their term will probably only last for from six months to a year, and may even be much shorter. Further, the continual lack of funds paralyses the work of the Board, for any profits which the railways may make are not utilised for developments or betterments, but are diverted to other purposes. The consequence is that all the lines are extremely short of rolling-stock, and that no development work in the direction of constructing branches, or connecting big towns to the existing railways by good roads, is possible.

Moreover, efficient management is rendered impossible by the outrageous conduct of the Chinese troops, who are perpetually on the move, for no apparent reason, holding up all ordinary traffic for days at a time, using the rolling-stock as barracks, and utterly wrecking it in the process. Also, when in garrison in the railway towns they make life a burden to the ordinary traveller, by crowding into any and every class of accommodation and indulging in free rides in the course of which the civilians are robbed and maltreated, while even the mail bags are rifled. Chinese troops are recruited from the lowest classes, are officered in many cases by men of low origin and are thoroughly out of hand. In fact it may be said that the army is the greatest curse of the country, for it not only involves a huge expense, but is absolutely inefficient, and its members are given to robbing and oppressing the peoples. Lack of money and the existence of such conditions as are described above make a progressive railway policy impossible and can only result in a state of stagnation which is undoubtedly bad for British trade.

It is therefore obvious that under these circumstances we do not get the full value for our money unless the line in which it is invested continues to progress. Hence the present system of loan agreements in which interest in the line ceases so long as we get our 5 per cent., has proved a partial failure in the direction of getting the full benefit for our manufacturers which would result if the Chinese railways followed a continuously progressive policy. On this account the principle of concession railways on the lines of the South Manchuria Railway is advocated as more to the mutual benefit of both nations, and more suited to the state of development of the country.

The South Manchuria Railway Company (a railway and mining concession), the largest commercial enterprise in China, in which the Japanese Government is the principal shareholder, took over the Russian rights in the Liaotung Peninsula after the Russo-Japanese War of 1904–5. These rights were for the management of the railway, which was under the absolute control of the Russian Government, and the rights of exploitation of all minerals found within the region traversed by the railway.

the extent of this region not being specified. In addition the railway may, according to the Japanese ordinance which sanctioned the organisation of this line in 1906, engage in the following branches of business in addition, namely: mining, water transportation, electrical enterprises, sale on commission of the principal goods carried by the railways, warehousing, business relating to the land and buildings attached to the railways, and lastly any business for which Government permission has been given.

These rights are fairly comprehensive, and how they were acquired the original Russian agreement does not show nor any subsequent Japanese agreement; but China has never been in a position to gainsay either of these nations, who do exactly as they please within the railway zone. For this concession the Chinese Government received nothing at the time it was granted, but according to the Russian agreement after the expiration of eighty years the line and all its property revert to China without payment, or the reversion may take place thirty-six years after the commencement of traffic on payment of the cost of the line.

Whether Japan has also subscribed to these terms is not known, but in 1905 to further protect her interests within this region she induced China to agree not to build, prior to the recovery by China of the South Manchuria Railway, any main line in the neighbourhood of and parallel to that railway, or any branch line in any way prejudicial to its interests. This clause in Japanese hands has seriously hindered the development of that part of Manchuria traversed by the Peking-Mukden Railway, as no distance at which paralleism ceased to be harmful was ever specified. A further extension of the lease for eighty years of the South Manchuria Railway was secured in 1915.

It is not suggested that rights so absolute as these would suit China, but there is no doubt at all that the material condition of the Chinese within the controlled area has improved as the result of Japanese exploitation, and as this is the first step in the direction of amelioration of the condition of the coolie class there is little doubt that some form of concession in which all developments within an area were under foreign control would be to the mutual benefit of both Chinese and foreigners.

The present condition of the area controlled by the South Manchuria Railway is an instance of the result of the working of a concession in China, and a concession not in the best hands, for Japanese methods are much too Prussian in dealing with a weaker nation, and the riff-raff of Japan has been allowed to overrun the country and engage in every disreputable trade absolutely unchecked. In spite of this the district has prospered, for Japan has sunk something like 13,000,000*l.* in development works of which the railway only absorbs half, the remainder being invested in steamships, collieries and steel works, the development of the port of Dalny, hotels, lighting and power schemes, &c.

The policy of this line since it was taken over by the Japanese has been continually progressive, the railway is perhaps more expensively run than most of the Chinese railways, but it is the cleanest and most comfortable line to travel on in China, and so far as it is possible to tell the other enterprises in which the railway is engaged are very efficiently managed. At any rate, the concern is exceedingly prosperous and there is very little doubt that the Japanese manufacturer gets the fullest benefit from the large expenditure on the railway, which amounted to over 3,500,000*l.* in 1914, for if there is one feature of Japan's policy which is unchangeable it is that of stifling all foreign competition.

The above results show that there is a considerable case for the concession railway from the point of view of improved conditions for the coolie class, and for a continually increasing market for the products of the concessionaires. In addition the Government, of course, incurs no extra debt and runs no risk of managing a losing concern, a rather important feature as China's financial difficulties are always increasing. Moreover, China would avoid the heavy charges paid for financing her railway loans in the past, for the most the Government has received per 100*l.* bond has been 94*l.*, and in a large number of cases previous to 1904 the sum has been as low as 90*l.*

The very natural objection to the concession agreement from the Chinese point of view is that they have no share in the probable profits, which have amounted to from 10 per cent. to 20 per cent. on some of the Government railways, after paying interest on the foreign loans. The ever-present fear of the partition of the country is also a great deterrent to the granting of concessions of this nature, for they necessarily imply police rights within the concession area, but increasing financial difficulties will eventually compel the Government to adopt a loan policy which is undoubtedly more to the benefit of the people if not to the official. For the three railway concessions granted with mineral rights have been undoubtedly beneficial. These concessions were the South Manchuria Railway, the Shantung Railway to the Germans, and now to the Japanese presumably for the time being, and the Yunnan Railway to the French. The results of the working of the first have been dealt with, of the second the result has been that the province of Shantung is in a more advanced state in the direction of mineral development than any other province in China, and of the third the opening up of a hitherto absolutely isolated province of enormous mineral possibilities. The first two have also amply paid their way from the point of view of the foreign investor, the last built at enormous expense, in the face of great natural and climatic difficulties, was financed by the French Government, and now pays working expenses.

The terms of the Sino-German agreement with regard to railway and mining concessions in the province of Shantung are perhaps worth citing as showing what has been acceptable to the Chinese in the past. These agreements ratified in March, 1898, and March, 1900, arranged for a Sino-German company to inaugurate a railway system for the province and to hold and develop mining property for a distance of 10 miles from each side of the railways wherever built. Germany further undertook not to introduce foreign troops or to transport foreign soldiers or munitions outside the 30-mile zone of the port of Tsingtau, but it was specified that if the offices of the company were seized by an enemy and control is lost, then the military forces of the Chinese Government would no longer assume the responsibility of protecting the line. This last clause, which permits foreign intervention if things get beyond the control of the local authorities, is extremely necessary, as such a state is frequent, and this clause would ensure the efficient policing of the district in order to avoid such interference. A much more satisfactory arrangement for police purposes would be a foreign officered Chinese force paid by the concessionaires, which would relieve the Government of all responsibility and not endanger their sovreignty. In the above agreement nothing was paid to China for the concession, but a clause was inserted reserving the right of purchase. No time was stated, however, or terms specified. This last clause would, of course, need modification to be acceptable.

THE BOQUILLA HYDRO-ELECTRIC POWER PLANT IN MEXICO.

THE great dam at Boquilla, in Northern Mexico, and the transmission of electric power from it, rank with the largest undertakings of this type, and are noteworthy also because the work was carried out in an arid district which is practically in the condition in which it was four hundred years ago, when the Spaniards conquered Mexico. A lake of 175 sq. km. (45 sq. miles) area, 60 sq. km. larger than the Lake of Lucerne, has been created by damming the River Conchos in its middle portion. The Conchos rises on the eastern slopes of the Sierra Madre and joins the Rio Grande del Norte, which forms the frontier between Mexico and the United States, at Presidio, after a course of 550 km. The lake lies in the Boquilla district, where the river breaks through a chain of mountains, and the lake level is at 1,321 m. (about 4,000 ft.) above sea-level. Three dams had to be erected to confine the new lake; the biggest dam, the Boquilla dam, is 32 km. (20 miles) west of Santa Rosalia, a small town served by the Mexican Central Railway. The hydro-electric power generated is sent to mines, and is later to supply light and power also to the city of Chihuahua, the capital of the State of that name. The project was conceived about 1903 by Mr. Emil Brönimann, an engineer from Berne, who conducted the preliminary operations until Messrs. S. Pearson and Son took the work up in 1909; the contract was soon taken over by the Mexican Northern Power Company, of Toronto, Canadian capital being largely interested in the scheme. The revolution in Mexico much delayed the work, which was only completed in 1916; considering these troubles and the primitive state of the district, the period cannot be regarded as over long.

The Conchos river may run dry for months, and may turn within a day into a torrent carrying hundreds of cubic metres of water per second. The Boquilla gorge is bordered by rock walls up to 120 m. (400 ft., roughly) in height. The main dam rests on limestone which has a dip of 15 deg.; its height is 74.5 m. (244 ft.), its length at the base 95 m. (312 ft.), at the top 264 m. (866 ft.); the thickness at the base is 61.6 m. (201 ft.), at the top 6 m. (19¾ ft.). In shape the dam is an arc having its apex on the water side; in section the dam is triangular, vertical on the water side. The mean depth of the lake at the dam is 70.5 m. (230 ft.); the average depth of the whole lake is estimated at 18 m. (60 ft.). At the dam the lake is tapped by six hydraulic pipes, 2.6 m. (8.5 ft.) in diameter, at a level of 43 m. (141 ft.) above the lake bottom; the pipes are first carried horizontally through the dam, which there has a thickness of 21 m. (69 ft.), and then cling to the sloping dam walls. At their lower extremity the pipes taper to 2 m. diameter (6 ft. 7 in.); each pipe feeds a Francis turbine with spiral casing, horizontal shaft, and a double guide-wheel system for 10,000 h.p.; the turbines are directly coupled with three-phase Westinghouse generators for 1,130 amperes and 4,000 volts at 360 r.p.m. So far only four turbines are installed, and the other two hydraulic pipes are only carried through the wall. A seventh pipe, of 0.75-m. (30 in.) diameter, feeds a small turbine which drives the exciter and the oil compressor working the sluices. From each of the pipes rises, in the dam, a vertical shaft up to the crown; from this shaft the sluices are operated. Near the bottom of the dam, and 12 m. (39 ft.) from the water a tunnel, 9 m. (30 ft.) high, 8 m. (26 ft.) wide, runs through the length of the dam; the tunnel was built mainly for the purpose of keeping any infiltration of water under observation, as the height of the dam and of the water beyond it was rising. When borings from this tunnel disclosed danger of leakage, cement was forced into the brickwork. Seen from in front, the power house rises to about one-third the height of the arched dam behind it. The other two dams are merely walls and overflow weirs, of great length, however. One of these dams has a length of 720 m., the other a length of 900 m. (0.56 mile). The latter consists of two sections joined at an angle of 150 deg., the apex being on the air side. Mr. Brönimann would have liked this dam to be stronger than it has been built, considering the danger from expansion in so long a dam.

The new lake has a length of 52 km. (32 miles) and a maximum width of 9 km. (5½ miles); it makes some very picturesque scenery accessible by boat. The River Conchos winds through the lake in a length of nearly 70 km. (43 miles). Full up to the level of 13 m. the lake will hold 3,750,000,000 cub. m. (132,400,000,000 cub. ft.) of water; at water depths of 10 m., 20 m., 30 m., 40 m., 50 m., 60 m., and 70 m., the water volume would be 16,000,000 cub. m., 60,000,000 cub. m., 185,000,000 cub. m., 468,000,000 cub. m., 991,000,000 cub. m., 1,540,000,000 cub. m., and 3,150,000,000 cub. m. The hydraulic plant has been supplied by Messrs. Escher Wyss and Co., of Zürich; the whole electric equipment is due to the General Electric Company, of Schenectady. So far there is only one high-tension transmission, of two independent lines, 76 km. (47 miles) in length, over to the mines of Parral. Each of these lines comprises three aluminium conductors, supported by towers 21.8 m. (72 ft.) in height, 200 m. (656 ft.) apart, of galvanised steel. The current is, in the power station, transformed from 4,000 volts up to 63,600 volts, and transmitted at this pressure. The further trans-

mission to the mines of Eulalia and to the City of Chihuahua, 130 km. (80 miles) distant, is planned at 110,000 volts.

THE NATIONAL PHYSICAL LABORATORY IN 1917–18.

SIXTEEN years have passed since the National Physical Laboratory was formally opened on March 19, 1902, by the King, then Prince of Wales, who was accompanied by the Princess. Actual work had already been done, first at Kew, and then in Bushy House, Teddington, for more than a year. Though the sceptic voice was not heard at the opening meeting, over which the late Sir William Huggins presided as President of the Royal Society, the needs of a national institution for industrial research and of a national testing station, to serve also as a scientific court of appeal in matters technical, were by no means generally admitted by industrials and the authorities. If anybody had then predicted that within a decade and a half the two departments of the opening day (physics and engineering) would swell into eight, that out of the pleasant gardens of that corner of Bushy Park would rise dozens of buildings and workshops, that a staff of 26 scientific workers and assistants would grow into a staff of 532, and that the annual expenditure of 5,000*l.* would multiply twentyfold, that opening ceremony might not have taken place. The supporters of the institution inside and outside the Laboratory did not deceive themselves as to the severity of the task upon which they had entered. Gradual development from a small nucleus, inadequately equipped and too modest almost to impress the critic, implied frequent alterations, re-erection of apparatus and very arduous, though instructive, work for the members of the staff who had little but devotion to their work to tempt them. Of the original assistants, Messrs. Boxall, A. Campbell, Constable, Harker, Hugo, Jakeman, Melsom, F. E. Smith, and Stanton still remain with the director, Sir Richard Glazebrook. Some others left with Dr. Chree in 1910, when the connection between Kew Observatory and the Laboratory was severed.

The splendid work done by the Laboratory, especially also during the war, has long since silenced most critiques. The two lectures which Sir R. Glazebrook recently delivered before the Royal Institution on "The National Industrial Research Laboratory"* well explained how it is that the university and the technical laboratory do not fill all the needs of industrial research, and characterised the lines on which the gradual expansion of the Laboratory has taken place and had to take place. Sir Richard then also referred to the changes made in the administration of the Laboratory with April last. The scientific control of the Laboratory is still exercised by the President and Council of the Royal Society and the General Board of the Laboratory, which comprises representatives of the great technical institutions and societies. But the property of the Laboratory is now vested in the Imperial Trust for the Encouragement of Scientific and Industrial Research, and the income is controlled by the Committee of the Privy Council for Scientific and Industrial Research. The financial responsibility thus passes out of the hands of Sir Alfred Kempe, Treasurer of the Royal Society, and the general change carries with it some alterations in the internal administration of the Laboratory. It is to be hoped that the knowledge of the official financial control will not stop the channels of private generosity. In agreement with recent donors it has been arranged that balances of former donations and future donations, offered for general or for special purposes, shall be applied as the donors desire and as the Executive of the Board direct. This applies to the recent donations of 200*l.* by the Institution of Mechanical Engineers for Alloys' Research, of 500*l.* by the British Aluminium Company for the same object, and of 250*l.* by the Institution of Electrical Engineers for Buried Cables' Research, as well as to the Tank Guarantee Fund and the unspent balance of Sir Charles Parsons' gift of 1,000*l.* These donations are apart from the grants for special researches made by the Department of Scientific and Industrial Research, either direct or through institutions, namely: 1,250*l.* for optical-glass research; 158*l.* for transmission of heat from surfaces to fluids flowing over them; 605*l.* for alloys (extension and equipment of the foundry); 115*l.* for lubrication research; 400*l.* for alloys and 66*l.* for hardness research (these two through the Institution of Mechanical Engineers); and 216*l.* for notched-bar impact testing (Institution of Civil Engineers).

As regards general features, the name remains the National Physical Laboratory; the Executive Committee, which retains the appointment of the staff—the clerical staff will probably pass under the rules of the Civil Service—is to present its report for the calendar year in December, but the annual visitation is to be in June as before. To meet the further demands for space on the already crowded site, some further land has been acquired to the north of the engineering building; this land extends to the main road and provides further access to the Laboratory. In this part of the ground the new aerodynamics buildings and the gauge workshops building are rising. Close to the administration building the builders are now providing accommodation for the testing of glass volumetric apparatus, a new line of testing which the development of British glassware has rendered necessary; this building will also contain an optical workshop. The Metallurgical Department has had to double the size of its foundry to gain further space for researches on alloys and on optical glass, and the addition of a third storey to the Julius Wernher building is now to be proceeded with; that addition was originally contemplated.

The Report of the Executive for the year 1917–18 foreshadows another important change. The primary electric standards of the country are in the custody of the Electrical Standards Laboratory of the Board of Trade, which is also charged with the testing of the secondary standards. This latter work has for some years been carried on in close co-operation with the Electrical Standards' Division of the Teddington Laboratory; the maintenance of dual standards is manifestly uneconomical as well as undesirable, however, and it is expected that Orders in Council entrusting the custody of the standards to the National Physical Laboratory will soon be issued.

The war has increased the work and responsibilities of the staff in manifold ways. Some of the members have been lent to official departments. All the chiefs of the divisions are members of various committees, and Messrs. F. E. Smith and J. E. Sears have been promoted to the rank of superintendent; Mr. F. J. Selby has been appointed Secretary to the Laboratory with equivalent rank. The number of members of the staff on active service is now fifty. Unfortunately, two names have to be added to the Roll of Honour. Mr. H. J. Head, a private in the East Surrey Regiment, who had joined the staff as a boy in 1913 and was reported missing in October, 1916, is now included among the killed, and Captain G. H. Millar, of Cambridge and the Tank Department, who had been taken prisoner and had only last year escaped from Döberitz, near Berlin, was killed by a seaplane accident in April last.

Of the enormous growth of the work, with some aspects of which the director dealt in his lectures, the Report can only give a very inadequate account. The statistics are impressive; but most of the research done is of a confidential character, and much of the regular research work, to be conducted with a staff depleted of many of its scientific members, has had to be altogether suspended, to the great regret of the workers, who will find it difficult to pick up the threads again and impossible to bridge the gaps in time records. In looking through our summary of the work of the National Physical Laboratory in 1917-18, our readers will bear these restrictions in mind. We begin our account with the work of the Engineering Department; the footnotes refer to our last previous accounts.

*Engineering Department** (Superintendent: Dr. T. E. Stanton, F.R.S., M.Inst.C.E.). *Notched Bar Impact Testing.* (Messrs. Stanton and R. G. Batson.) The two reports on this work (the third and fourth reports of the series), submitted to a Sub-Committee of the Engineering Standards Committee during the past year, deal particularly with the questions (1) whether the irregularities of the results of individual tests are inherent to the method, *i.e.*, whether the manner of obtaining the work done in fracture by noting the height fallen through by the hammer before striking the specimen, and the height to which it rises after fracture, is sufficiently accurate; or (2) whether these irregularities are due to want of homogeneity in the materials which, though of identical chemical composition, may differ as to the orientation of the crystalline structure at the bottom of the notch. As regards question (1) a comparison has been made of tests, conducted by different observers in machines of different design, of specimens as nearly identical in composition and crystalline structure as could be obtained by careful selection and heat treatment. The broad conclusions drawn from this comparison of the tests of specimens, normalised and tested at the Laboratory and also normalised and tested elsewhere, are: (*a*) For ordinary low-carbon steel, carefully normalised, the method of measuring the work of fracture is one of reasonable accuracy; "in three sets, each of six specimens of the E.S.C.A. steel (0·19 per cent. carbon), *e.g.*, the average variations from the mean work of rupture were 4·7 per cent., 2 per cent. and 3·2 per cent. respectively; (*b*) for high-carbon steels the irregularities were much more marked; three sets of ten specimens of a 0·62 carbon steel, normalised by Mr. Saniter, showed average variations from the mean work of rupture of 12 per cent., 6 per cent. and 12 per cent. respectively; the cause of this greater irregularity seemed to be the want of homogeneity in the steel.

The sub-committee then decided to investigate the effect of the root radius of shallow-notched specimens in the detection of faulty heat treatment. A shallow V-notch, 2 mm. deep, of 45 deg., was provisionally adopted, and the Laboratory was asked to make a series of tests on sets of specimens, 10 mm. by 10 mm. by 53½ mm., with root radii of $\frac{3}{8}$ mm. and of ¼ mm., the specimens to be of ordinary mild steel and of high tensile steels, in both cases correctly and incorrectly heat-treated. The tests showed definitely that in order to detect faulty heat treatment with these shallow notches the root radius of the notch should not exceed ¼ mm. When the root radius is larger, the notch must be made deeper, as in the case of the Charpy notch which appears to be the most sensitive for the detection of faulty thermal treatment. In the Charpy test the notch has a root radius of $\frac{1}{12}$ mm., being drilled with a diameter of $\frac{1}{8}$ mm. to a depth of 5 mm.; the well-known serious objection to the Charpy test is the almost insuperable difficulty of drilling such a hole in the hard steels now of common use, and the sub-committee are hence in favour of recommending the standardisation of the shallow-notched specimens as stated. The further particular problems now under investigation are the need of test bars of different sizes; the question of supporting the test bar at both ends or fixing it at one end; the influences of the cross-section and of the volume of the bar on the work of fracture, and whether any relations can be found for reducing the results on one size to those on another; the influences of the velocity of striking and angle of the bend of the bar; application of notched bar tests to carbon steels in industrial products.

Hardness, Wear and Indentation Tests (Mr. Batson).—The machine designed for studying the wear caused by sliding abrasion and the effects of varying the relative velocities of the surfaces and the pressure between them has been required for other urgent work, and this research has therefore been delayed. As regards the indentation tests by the Brinell ball the standard conditions, a ball of 10 mm. diameter and a fixed load of 3,000 kg., are inconvenient for very soft materials and for very thin test-pieces. Various methods have been adopted, in the Laboratory and elsewhere, for bringing the results obtained with different balls and loads into line, and there are various ways of taking measurements. Mr. Batson finds that a hardness number approximately independent of the ball diameter can be obtained by the method which Mr. Harold Moore, of Woolwich, suggested in a communication to the International Association for Testing Materials. The method is based on Meyer's

* See ENGINEERING, March 8 and 15, 1918.

* ENGINEERING, June 22, 1917, page 598.

conclusion that, for the same material, the load divided by the area of the indentation is constant for the same angle of indentation; Moore suggested that the angle should be such that the diameter of the indentation was half of the diameter of the ball used. For certain purposes, *e.g.*, for hardness determination at high temperatures, impact indentation tests have the advantage that the ball is in contact with the material for a short period only and that the period of applying the load need not be considered; this period is an important factor in the static Brinell tests, and we described recently* a method by means of which Guillery has succeeded in accelerating the test without impairing its accuracy. As regards the dynamic (impact) indentation tests, Mr. Batson has conducted a series of experiments to co-ordinate the previous work, in which Roos, in Sweden, used a 10-mm. ball, whilst Martel substituted a conical point for the ball. According to Roos the energy of the blow is proportional to the square of the spherical area of the indentation, according to Martel proportional to the volume of the indentation; the two statements appear incompatible with one another. The impact experiments mentioned, which are made with weights of 2 kg. falling through heights ranging from 5 cm. up to about 30 cm., confirm both the statements, however, with a certain restriction; Martel's rule of proportionality is found to hold for both the ball and the cone, but the relationship given by Roos applies to the ball only for the small indentation depth of ordinary test work.

Fatigue Resistance (Messrs. Batson and G. A. Hankins).—The study of the fatigue resistance under combined stress tests, the value of which is more and more recognised by designers, has unfortunately been in abeyance during part of the year, as the machine was wanted for urgent war work. Additional fatigue-testing machines are under construction and one of the Wöhler machines has been adapted for testing specimens at steady temperatures up to 250 deg. C. by immersing the rotating specimen in an electrically-heated bath of cotton-seed oil. In the case of air-hardening nickel-chrome steel the fatigue range was at 250 deg. C. 20 per cent. lower than at normal temperature; light alloys have similarly been tested with interesting results. The new machinery for this investigation comprises an electrical furnace of special form.

Valve Steel at High Temperatures (Mr. A. Bailey).—In the tensile and compression tests of some valve steels at temperatures ranging from 650 deg. to 950 deg. C., a vertical 10-ton Buckton machine and a furnace consisting of a silicon tube wound with platinum foil are used. The specimens are of small dimensions, and the temperatures are measured with the aid of thermo-couples of platinum/platinum-iridium, graduated from 0 deg. up to 1,000 deg. by steps of 10 deg. C., the couple being tied to the test-piece so that the junction is at the middle point. All the strengths fell off to low values in the high-temperature range mentioned, which includes the characteristic temperatures, and the results are very interesting.

Frictional Resistance. Surface Roughness and Heat Transmission (Dr. Stanton and Miss D. Marshall).—The effect of surface-roughening on the heat transmitted from hot bodies to fluids flowing over them has further been studied† with some unexpected results. Water is sent through brass pipes, internally smooth or roughened, externally heated by insulated coils. It was observed that with the degree of roughening obtained with the aid of a screw-cutting tool in the case of 1½-in. pipe, the heat transmission per unit surface per degree difference of temperature between the metal and the water could be increased in the ratio of about 2·5 to 1 for the same mean velocity of flow. The rule of Reynolds that the heat transmitted from a hot surface to the fluid moving over it is proportional to the frictional resistance between surface and fluid was thus practically confirmed, and it appeared that if the surfaces of air-cooled engines and radiators could be roughened in this way, considerable economy might be effected in the design of aeroplane engines. A series of copper gills were therefore fixed to an engine and set up in a wind channel; current from accumulators was circulated through the gills, and from measurements of the current and of the resistance the temperature of the gills and the heat dissipated were deduced; the gills were first smooth, and then roughened by means of corrugated steel dies. This roughening, which made the gills assume the appearance of files, had practically no effect on the heat transmission, however, the result indicating that the convection of momentum to the rough and the smooth surfaces was approximately the same; this discrepancy is further being investigated. At the request of the Munitions Inventions Department Miss Marshall also determined the frictional resistance of the flow of a liquid (water) through a pipe system composed of a spiral coil with various valves and T-pieces. The resistance in a section was estimated by measuring the pressure-drop between two points at the ends of the section (from the heights of water columns) and by weighing the quantity of water transmitted in a measured time, observations being taken over a wide range of speed. By applying the principle of similarity the relation between frictional resistance and velocity established for water could then be extended to the case of the gas as to which the inquiry had been made.

Stream-Line Struts. Personal Error (Mr. Hankins).—To compare the value of various woods for long stream-line struts, the strut was tested with an axial end load, each end being made free to take up any angular position by the aid of compound knife edges. From the modulus of elasticity, found for each material by a bending test, the critical load that would cause indefinite bending was calculated after Euler's formula for a simple strut, and these calculated loads agreed remarkably well with the observed loads producing failure; the results indicated that the special device adopted made the end constraint negligible. Mr. Hankins also designed a simple apparatus to replace the elaborate clockwork mechanism used in physiological laboratories for testing the quickness of response of the hand to a motion observed by the eye. A stout thread is wound round a pulley and unequally loaded at the two ends; the pulley rotates as the heavier weight descends, and the observer has to close an electric circuit and thus to arrest the weight as soon as it appears below a screen; from the distance which the weight continues to traverse the quickness of response is judged. The average response takes place within $\frac{1}{10}$ second, but it varies much.

Internal Pressure Test of Oxygen Cylinders (Mr. J. H. Hyde).—The cylinders, 3 in. internal diameter, 2 ft. long, were tested in a simple apparatus. The cylinder under test was completely immersed in the water of a steel pipe closed at both ends by steel plates, the cylinder being suspended by a brass fitting, which effected connection with the pressure supply from the top plate. As the pressure, which was measured on a Bourdon gauge, was increased, the water rose in a water-gauge tube, connected with the water chamber, and the corresponding increase in the cylinder volume was thus determined. The pressure was removed when the yield-point was reached—the point being fairly definite—and the small permanent increase in volume was noted.

Aerodynamics (Dr. Stanton, Messrs. E. F. Relf, J. R. Pannell, A. Fage, with other assistants and volunteers).—Mr. L. Bairstow, F.R.S., having accepted an appointment at the Air Ministry, Dr. Stanton has undertaken the duties of superintendent of the division, the work of which is merely indicated in general terms in the Report. Two new air channels of largest dimensions are under construction in the new aerodynamic buildings, and their design and eddy motions are further being studied. The balances are constantly being improved, a new air-screw balance and a new apparatus for lift measurement have been constructed, and modified apparatus for the measurement of rotary derivatives have been devised. Much work has been done on models of all types of aircraft, both monoplane and biplane, airships and kite balloons. Many of the investigations are in response to special inquiries from the Air Ministry, but every endeavour is made to bring the researches into their proper relation as part of an organised scheme.

Road Board Laboratory (Mr. Batson).—Seventeen tests have been made on road stones, but the general work of this board has almost been suspended during the year.

The William Froude National Tank (Messrs. G. S. Baker, Superintendent; G. L. Kent, G. H. Bottomley, A. W. Riddle; Miss E. M. Keary).—When the King visited the Laboratory for the second time, in November, 1917, he was shown models of a fabricated ship and of a self-propelled submarine, and he also witnessed some novel experiments. The Tank Department has been conducting several special investigations into the conditions of collisions and foundering, and many of the 39 separate investigations completed since August, 1914, of vital importance in their direct bearing upon the war, could hardly have been carried out in any other tank of the kingdom. The changes in the status and financial control of the Laboratory also affect the tank; the Advisory Tank Committee will continue to act as before, however, all fees will be applied to the work of the Tank, and funds guaranteed by donors will be held by the Trustees of the Imperial Trust as an endowment fund for special purposes. These guarantee funds have been of the highest direct and indirect assistance to the research work of the Tank, and as several of the guarantees will soon expire, the Tank Committee earnestly hope that each guarantee will be continued and renewed.

The long overdue check of the rail-level was carried out over the central 300 ft. of the tank in August, 1917, with the aid of the same 40-ft. base water gauge which served for the original levelling up; the levels of the rails on the two sides of the tank were also compared. The maximum difference of level found was 0·065 in., the wear of the rail joints is quite small, and only a few joints require attention. Two of the driving motors have been overhauled, but it is difficult to find time for laying-up the other two. During some severe stability tests a number of consecutive runs was made with the truck at absolute speeds of 24 ft. per second, without any hitch. The water consumption in the big tank remains small; the small tank had been emptied, but it is still without its motor for driving the impeller.

Models Tested.—As the building of fast liners is in temporary abeyance, half of the 41 forms submitted for tests during the year referred to the standardisation of types. The best result obtained has been a reduction of 13 per cent. in resistance without any variation of displacement or dimensions and without diminution of stability. In several cases tests at various draughts have been asked for, in accordance with the recommendation of the Committee. Many tests of standard cargo vessels have been conducted for the Admiralty, and satisfactory results have been obtained with straight-line forms of fabricated ships.

Research Work.—Research was not resumed till the end of November, 1917. Mr. Kent hopes to have a paper on the effect of varying beam ready for next year's spring meeting of the Institution of Naval Architects. The investigation of the possible effect of longitudinal motion on the transverse stability of a ship was not included in the approved programme for last year, but some progress has been made with this work, the four additional forms tested varying from full cargo boats to light skimmers. As long as wave-making is small, the effect, which varies with each form, is negligible; longitudinal motion does not count for cargo boats, therefore, but in high-speed destroyers it leads to a loss of 2 in. of metacentric height. Properly-shaped skimmers gain in metacentric height, when they arrive at the planing condition, but before reaching this condition there is a marked loss of stability over a fair range of speed, the loss amounting to 7.6 in. of metacentric height for a 60-ft. vessel. Mr. Baker and Miss Keary gave an account of this research before the Naval Architects last spring.* Some resistance experiments have been made in the tank with a model form which has also been tried in Sir John Thornycroft's tank, which differs in dimensions from the Teddington tank; in this smaller tank the models were towed by weighted wires passing over pulleys. The inquiry into navigational effects of ships, actually passing one another

* ENGINEERING January 25, 1918, page 91.
† ENGINEERING, June 22, 1917, page 599.

* See ENGINEERING, May 17, 1918, page 545.

or merely in proximity, upon each other, especially in narrow and shallow water, could be proceeded with at present, and the hope is expressed by the Committee that permission will be obtained at an early date to publish such data of official experiments as have a general bearing on this subject. This hope and wish will generally be endorsed; there is a widespread feeling that much of the now suppressed information should be made available.

(To be continued.)

NOTES.

Nitric Acid from Nitrogen Oxide.

In most of the modern furnace processes for the fixation and oxidation of the atmospheric nitrogen, nitric oxide NO is produced which, on being mixed with air, takes up more oxygen with the formation of red-brown vapours of NO_2; these vapours are absorbed by water yielding both nitric acid HNO_3 and nitrous acid HNO_2; the latter is decomposed, giving again NO and some more HNO_3. None of these reactions can easily be controlled in practice, however. The NO gas leaves the electric or other furnace in which it is prepared hot and has to be cooled considerably below 600 deg. C. before it will effectively combine with the oxygen of the air; that cooling requires large spaces. The absorption of water again is incomplete and calls for large towers packed with stoneware, coke, &c., in which the gas meets the water descending through the stoneware balls or fragments; there is thus much pumping, and the resulting acid is after all diluted and has to be concentrated. Finally there is generally loss of nitrous vapour with the excess of air to be used. Many processes have therefore been tried to hasten and facilitate the reactions, and some recent experiments on these lines conducted by G. B. Taylor, J. H. Capps and A. S. Coolidge, of the U.S. Bureau of Mines, are described in the Journal of Industrial and Engineering Chemistry of April last. In the first instance they tried to find a better absorbent than water for the nitrous vapours. A mixture of sulphuric acid and chromic acid seemed promising, as the chromic acid would further oxidise the oxides and might be recovered. But they observed that the acid mixture had to be used at the very inconvenient temperature of 150 deg. C., and that the recovery of the chromic acid from the chromium sulphate formed could not profitably be carried out by electrolysis, though it can be effected with the aid of platinum electrodes and alundum diaphragms. Electrolytic oxidation of the nitrous vapour dissolved in sulphuric acid alone also failed. They therefore returned to absorption by water and diluted nitric acid. They packed five towers with coke which was flushed at intervals with diluted nitric acid; the first of the five towers was left empty to serve as oxidation tower. They found that they could absorb 85 per cent. of the acid in the first three towers, and that an increase of the number of towers for the purpose of diminishing the loss of acid was hardly advisable. The upper portion of each tower was left empty to provide further reaction space, for the NO and oxygen must be properly mixed to combine, though the reaction itself is rapid under suitable conditions. As the rate of NO gas supply was increased from 1·25 cub. ft. per minute to 2·5 cub. ft. and 4 cub. ft., the efficiency of absorption fell from 98 per cent. to 95 per cent. and 91 per cent., but the total recovery of HNO_3 increased from 23 lb. to 44 lb. and 68 lb. in 24 hours. Thus the rate of gas flow should not be too slow. At the same time the excess of oxygen (over the theoretical amount necessary for the complete oxidation) should not fall below 5 per cent., nor be too great, lest the gas mixture be too diluted, and too much fine mist of acid vapours escape from the towers. This loss of acid mist was much reduced by the aid of Cottrell's precipitator; the vapours were sent up a glass tube in which a platinum wire, stretched axially, served as the one high-tension electrode, the other electrode, wire coiled round the tube, being earthed. The experimenters conclude by recommending that very ample reaction space should be provided, and that atomising sprayers be used, the fine mists of acid finally to be precipitated by the Cottrell apparatus. The use of the electric precipitators is certainly spreading, and they have done good service; but it must also be acknowledged that they do not appear to clear gases and mists of the very finest particles so well as of coarse particles.

Reinforced Concrete and Salt Water.

When a report of the waterproofing committee was discussed by the American Society for Testing Materials in 1912, some members argued as if defective concrete walls and disintegrating piers could be strengthened in the manner that illnesses are sometimes said to be cured, simply by denying their existence. Professor H. J. M. Creighton, of Swarthmore College, Pennsylvania, referred to this meeting in a paper on "Reinforced Concrete *versus* Salt, Brine and Sea Water," which was brought before the Faraday Society on July 23 last. That in laboratory experiments blocks of cement mortar and concrete in which iron rods are inclosed can be destroyed by sodium and magnesium salt solutions, especially when containing chlorides as well as sulphates (according to Bates, Phillips and Wig of the U.S. Bureau of Standards) needs no confirmation, and that many marine reinforced concrete structures have failed is equally certain. Professor Creighton mentioned several cases. Young's "Million Dollar" pier at Atlantic City began to corrode in two years and was swept away by a storm in 1912. At the Key West extension of the Florida East Coast Railway one of the viaducts, steel-reinforced, deteriorated in the same period, and in consequence all the viaducts have, since 1909, been constructed with a cement low in magnesium and sulphate and without reinforcement. In the Philippine Islands the cracking of reinforced concrete structures is markedly prevalent according to the report of J. L. Harrison, of Iloilo, 1916, and salt has been found in all concretes in which the steel had become rusty; in order to keep salt out of the concrete, it has been resolved to wash the sea sand and gravel from the beach with fresh water before adding it to the cement. On the other hand concrete, even reinforced, may on the whole be relied upon to remain sound for long years, and the failures may be due to bad materials, bad proportions, bad mixing and other causes, quite apart from the action of salt. Though the reactions between salt solutions and cements are not fully cleared up, one understands why iron embedded in cement should rust more readily in salt water than in fresh water. An iron rod placed in distilled water sends positive ions into the water, becoming itself negatively electrified; but that action stops very soon owing to the electrostatic attraction between the two charges. Any salt present is dissociated, yielding hydrogen ions and hydroxyl ions; the latter combine with the iron which rusts, expands and cracks the concrete; the former, the hydrogen ions, may remain absorbed, but Creighton was able experimentally to prove the slow generation of hydrogen in such cases. Local electric currents and still more currents leaking into the concrete, hasten the rusting of the iron and cracking of the concrete. To a certain extent the rusting of the iron in the concrete can be prevented by painting the iron; water-proofing the concrete will do good service, especially if the surface can further be protected against mechanical injury. The Institution of Naval Architects discussed these questions with respect to concrete ships in the last spring meeting (ENGINEERING, April 5, 1918, page 359). Creighton proposes to waterproof concrete by the Schoop metal-spraying process. He does not say which metal he would choose, and how the process is to be applied and at what costs; to expect a "very thin layer of suitable metal" to keep intact on piers is certainly asking for a good deal, however. In the other part of his paper Creighton dwells on his observations concerning the destruction of concrete walls and floors by brine in various towns and localities; we referrred to these observations on page 46 of our issue of January 11, 1918.

The Sign of the Zinc Pole in a Battery.

The vexed question has once more cropped up whether the zinc terminal of a primary battery should be called the negative pole—which is the actual common practice—or the positive pole. The problem rather presents itself under a different aspect, as we shall see, but it comes down to this question. Scientists have changed their standpoint several times since the days of Volta. The introduction of the secondary battery caused renewed difficulties to the student already bewildered by the disagreement of investigators. The plate, which was the anode or positive pole during the charging period of an accumulator, became the negative electrode during the discharge, which is the essential period for an accumulator. Of late there has been fairly general agreement as to the sign of the zinc pole or of the terminal on the electrode which corresponds to the zinc of a primary battery, and it does not seem advisable to disturb that agreement by renewed discussions as has recently been done chiefly by American electrochemists like G. N. Lewis. The controversy is as old almost as the fundamental experiments of Galvani and of Volta of 1786. Galvani suspended frog legs by a copper wire from an iron railing and observed that the legs contracted when they happened to come in contact with the iron; he was studying the influence of electricity on nerves, and he ascribed the phenomenon to animal electricity. Volta opposed this view, and maintained that the essential thing was the direct or indirect contact between the iron and the copper. Both views found supporters at the time; later, Volta's theory conquered. At present few scientists probably would care to express their opinions on animal electricity and on contact electricity in a few words. In Volta's pile the zinc was called the positive plate and the copper the negative plate. The pile soon made room for the battery of cells, however, and in cells the chemical forces between the metal and electrolyte rather than the contact forces between the metals are considered the source of the energy. Berzelius already designated the more oxidisable of two metals as electropositive with respect to the other. But in the Daniell cell the zinc pole is marked negative, and the copper pole positive. That is because we have to distinguish between the current in the cell, which flows from the zinc through the electrolyte to the copper, and the current in the outer circuit which flows from the copper to the zinc. Now the external circuit gives us the current we want for doing work, and as this explanation brings the dynamo and the primary battery into line as sources of electric energy, it finds favour with engineers and physicists. It is less acceptable to the electrochemist, however, who has to calculate the electromotive forces of complex cell combinations from the single potentials of the electrodes in their electrolytes and who, in corrosion problems, is more interested in the phenomena of the internal circuit than in those of the external circuit. The rule just given for fixing the polarity is, moreover, based on an argument which really does not help us much, that is, that the current flows from a place of higher potential to one of lower potential. On that rule the same zinc plate has the higher potential of the two metals within the cell, and the lower without the cell. The real difficulty is about the single potentials. Some scientists said that a zinc electrode assumed a negative potential in a solution of its sulphate, others preferred to call it positive. According to Nernst's theory of solution pressure, zinc sends positive ions into its sulphate and thereby becomes negative; others called it positive for that reason, and objected that, since zinc has more free energy than copper it must be considered positive. In a paper on "The Sign of the Zinc Electrode" (Journal of Physical Chemistry, May, 1918), Professor Wilder D. Bancroft tries to show that the difficulty is not real, and that it vanishes, when we say that the chemical potential of the zinc in the cell is greater than the chemical potential of the copper, but its electrical potential is less. With an electrode which forms anions, he proceeds, the two potentials have the same sign, with electrodes which form kations they have opposite signs. His arguments, we are afraid, do not clear up the difficulty, though the distinction between chemical and electric potential may concisely have been stated by Gibbs, as he says.

New Dry Dock in Norway.—A dry dock is about to be constructed at Aalesund, Norway, where it appears to be much needed. It will accommodate ships up to 4,000 tons.

LITERATURE.

Kinematics of Machinery: A Text-Book on Mechanisms and their Properties, with many Practical Applications for Engineers and for Students in Technical Schools. By ARTHUR WARNER KLEIN, M.E., Professor of Mechanical Engineering, Lehigh University. London: Hill Publishing Company. 1917. [Price 10s. 6d.]

IN this work the author is more concerned with the method of teaching the principles of kinematic analysis than with the science itself. The book is more pedagogic than theoretical, and the method pursued mainly graphical. Proofs of propositions and of statements are generally not given, reference being made to some standard work on projective geometry or to Weisbach-Herrmann's "Mechanics of Machinery." Sometimes a graphical confirmation is substituted for a rigorous proof, the student being recommended to obtain a solution by a second construction, apparently distinct, and to compare the results. Such procedure simply shows that identical results flow from following certain rules, it affords no guarantee that the proper solution of the problem has been found. In his warm championship of graphical methods, the author has failed to make his book self-contained, or he relies on proofs furnished in appendices to buttress the weakness of chapters in the text. For example, a formula is given for the Criterion of Constraint,

$$J = \frac{3N - 4 + \gamma - p}{2}$$

connecting the number of joints in a mechanism J with the number of links N, of independent prismatic chains γ, and of the number of higher pairs p, if they occur in the mechanism, but offers no proof in the text. The reason given for its omission is curious and worthy of consideration. "The author does not regard its study by the student as essential to the intelligent and working understanding of the criterion or of its application." This is perfectly true, the whole course shows that if the student will apply the rules and methods prescribed, he will solve the problems proposed. And apparently Professor Klein is willing to substitute "desirable" for "essential," since he adds: "It is intended that the ordinary student be spared this addition to his already arduous labours." This tenderness for the student strikes us as a little ill-placed, for the proof imposes no very severe tax on time or capacity.

The sentences quoted explain generally the purpose of the author and indicate the weakness and the strength of the book. Fully convinced of the advantage to be gained in point of clearness and simplicity by considering the principles of motion apart from all confusing accessories, he would make these principles available to all. As an experienced teacher he spares himself no pains in making the path smooth for those that have to tread it, though this devotion may not prove the best discipline. But it is impossible not to admire the thoroughness with which the author has laboured to give light and brightness to a rather unattractive subject, and to remove the difficulties that naturally attend analytical solutions.

The object of the treatise is to trace the displacements, velocities and accelerations of mechanical arrangements, that by reason of constrained motion constitute a mechanism. Following the Reuleaux system generally, it is shown that every mechanism can be analysed into a kinematic chain, and since each link in the chain can in turn be fixed, different mechanisms can be represented as inversions of the same kinematic chain. Very skilfully and with ample illustration it is shown how to find the generalised kinematic skeleton, resolving complicated forms into constituent quadrics, or hexagons, in order to demonstrate the manner in which motion is built up, with the view of furnishing the geometric essentials for the determination of all degrees of motion.

Professor Klein's plan of trusting entirely to graphical processes for the elucidation of actual mechanism can be best justified in the case of tracing the successive relative positions occupied by a moving point. The students may be expected to have learnt their geometry elsewhere, and problems connected with roulette construction should give no trouble. Other examples include the path of a pencil point of an indicator, and deal with cam construction. A more thorough insight into the laws of formation of mechanics is sought and an appreciation of the increased power to be acquired by the kinematic study of mechanisms should prove of inestimable advantage whenever special machinery has to be designed.

The student is next introduced to velocity diagrams. He finds a wider significance attached to the "instantaneous centre," and being given a particular kinematic chain is expected to find all the instantaneous centres by applying the elementary theorem of Three Centres. The utilisation of the vectorial method has some advantages over that of proceeding by instantaneous centres, especially if attention is confined to absolute velocities, but for teaching purposes many important points are best illustrated by the method of centres. It is very good training to be obliged to find all the instantaneous centres, whether the theorem of three centres applies, or recourse has to be had to special local construction, where, owing to indeterminate intersections the simpler method fails.

Adherence to the method of instantaneous centres leads to an interesting chapter on the kinematic analysis of mechanisms. The presence of a quadric chain in any mechanism offers a means for determining six instantaneous centres, four directly and two others by merely producing the opposite sides of the quadric. Hence the desirability of finding the generalised kinematic skeleton, and resolving it into its constituent quadrics, either by the successive addition or removal of jointed binaries. Professor Klein recommends the building up process as the simpler for beginners, and some devices that he suggests seem admirably arranged to assist the student. His employment of the temporary quadric has much to recommend it.

Two chapters are given on acceleration determinations, the motion of the quadric crank being first treated as uniform and afterwards as the more general case with variable motion. The student will find in these chapters many opportunities for applying his geometrical reading: several very interesting propositions are enunciated and assumed, but no demonstration is given, though references to books where these can be found are mentioned. In the important section on the determination of the centre of acceleration this omission is striking, and the description of the "polar diagram" and of the formation of images by acceleration vecters might have been extended with advantage. On the other hand, various devices are described pointing to the reproduction of that fundamental kinematic unit, the quadric chain, that will prove practically convenient, and greatly facilitate the determination of acceleration problems. The discussion and application of methods to the slider crank train where the crank rotates with uniform known velocity is a thorough and illuminating model exercise.

In further consideration of accelerations, it is shown that the parallelogram of motions while sufficient in the case of displacements and velocities fails in regard to completeness in the case of finding the resulting acceleration of a given point. The necessity of an additional term is demonstrated with more thoroughness than is usual in this treatise, and is expressed as the law of Corioli's in the following terms: "If a point F moves with the velocity $v\gamma$ and acceleration $A\gamma$ upon a curve rr that has any motion in a fixed system, and if the point of the curve coinciding with the point F at the instant under consideration has itself an acceleration Ap in its own curve pp on the fixed plane, and if Wp is the angular velocity of the curve rr about its instantaneous centre then the resulting acceleration"

$$A\sigma = A\gamma + Ap + 2v\gamma wp.$$

where the signs of addition represent a vectorial sum. We have quoted this law or deduction at length because the author states that the principle has failed to attract the attention of English writers of text books. This omission Professor Klein regrets as very unfortunate, because not only does the law affect all governor-gear action, but because it is very helpful in discussing the dynamics of mechanisms. With the prominence and in the form given here, the author's statement is probably correct, but where its introduction is necessary its equivalent will be found.

Two appendices are added to the treatise, intended rather for the teachers than the students. The former, dealing with the Criterion of Constraint, has been already mentioned; the latter treats velocity and acceleration determinations by the method of polygons or images. The construction of velocity images in particular cases is worked out in considerable detail, and of the acceleration problems some that occur rarely in practice are discussed on account of the excellent practice they furnish in this application of the principles involved, and for the illustration of certain essential features in the procedure. Remembering that the book illustrates the course followed at Lehigh, the impression produced is that the training in that university is very thorough and practical. The use of such a text book in engineering colleges and training schools cannot but tend to raise the standard and help to maintain a high degree of efficiency.

The Calculations for Steel-Frame Structures, designed to Comply with the Requirements of the London County Council (General Powers) Act, 1909. With Notes on the Application of Theory to Practical Design. By WALTER CYRIL COCKING, M.C.I., M.J.I.E. 313 pages, with 78 illustrations and 6 folding plates. London: Scott, Greenwood and Son, 1917. [Price 5s. net.]

UPON cessation of hostilities it is reasonable to suppose there will gradually be some resumption of activity in the building industry—the revivification of old schemes, the formulating of new, with preparation of architects' plans, and in due course, steel-frame details, and letting of contracts. When that will be no one can at present say, but when it does happen, Mr. Cocking's book should be of use—of more particular use be it noted within the area covered by the powers of the London County Council, to the satisfaction of whose building acts, regulations, and procedure, the author gives minute attention.

Opening with a preface somewhat discursive and flamboyant, but true as to the general tenour, the author proceeds to give extracts from the London County Council (General Powers) Act, 1909,—chiefly dealing with limiting loads, stresses and foundation pressures—no doubt conveniently placed in such a book—and from this goes on to deal with the survey of sites and preparation of site plans, following which is a statement of simple principles involved in design and methods of application to beams, with examination of shearing stresses, rivet pitches, &c., extending the inquiry to the case of inclined beams.

Floors are dealt with in detail, including concrete embedded joists, with special cases of floor beams excentrically loaded. Grillage foundations, pillars centrically and excentrically loaded, framed trusses and roofs are also treated. Cases of combined stress are examined, and particular instances of riveted connections analysed by way of warning. A useful collection of approximate formulæ is given, some of them very good. The majority may be memorized, though there are instances a little too complex to justify their existence as approximations only. A set of model calculations is also given, preceded by some pages of explanatory text.

The orderly arrangement of this matter is in structural design, with its multiplicity of parts essential both for the designers own convenience, and to meet the requirements of the controlling authority. This should be well studied by those to whom this branch of work is unfamiliar. Six folding plates appear at the end of the book, giving the method of displaying particulars of a typical structure.

The treatment of the subject is on the whole satisfactory, and in some instances distinctly good, but there are matters to which it may be well to call attention as either debatable, or definitely to be traversed, and other matters of interest which should not be dismissed without remark. Those who have had much to do with architects will be aware of the invincible objection they have to giving a dimensioned site plan, or, indeed, any dimensions but those of floor heights, and, perhaps, floor thicknesses—this throws upon the designer of steel-framing the onus of ascertaining as best he may the necessary particulars. The methods of measuring up a site as explained by the author seem to be satisfactory, but he does not indicate, perhaps

wisely, which of the three methods given is considered the most reliable, as this must depend in a great measure upon the freedom, or otherwise, of the site from obstructions.

Considerable pains are taken to elucidate the development of stress in the parts of a beam, whether as direct stress parallel to the neutral axis, shear stress, or stress in rivets, and this will be found helpful to some, but there is occasional obscurity.

The chapter on inclined beams is useful but does not exhaust the subject. The stresses in such beams are largely affected by the method of support, and this is not sufficiently made clear, further the beams or columns supporting the ends of inclined beams may also be affected in a considerable degree by the same considerations.

The treatment of floors—otherwise unobjectionable—is marred by the author's method of dealing with concrete encased joists. That these are considerably increased in strength by this mode of construction is not to be denied; indeed, tests made by Mr. Barclay Parsons show an enhancement of weight-carrying capacity of about 40 per cent. for joists with but a meagre concrete cover. This increment may properly be taken into account, but the author's handling of the matter is open to grave question, and the tables he gives of safe loads on joists so encased, are somewhat startling. For instance, in the case of small joists of 8 ft. span the results vary between 200 per cent. in excess, and 35 per cent. in defect of that proper to the joist un-encased. In making these tables the methods of reinforced concrete design are said to have been applied, but the author appears to have neglected the examination of adhesion, or "grip" of concrete required to develop stress in the steel, and has further, by rigidly limiting the concrete stress to an assumed amount, credited the combination of joist and concrete in some cases with less strength than the joist would have by itself, so that the effect of encasing seems to be a lowering of the resistance offered. A method of calculation giving such results cannot be approved.

In treating the case of beams excentrically loaded the author—having borrowed a fairly satisfactory mode of estimating maximum stress—not liking the results arising from its use, achieves a modified result, more to his taste by halving the calculated excentric effects. That procedure has for recommendation the virtue of simplicity, but possesses no other claim to regard. The doubt conveyed by this treatment is based on the contention that if excentric loading induced such stresses as are given by the calculation in its primitive form, there would be visible effects, but as a fact such effects are visible in many cases, and the author has no occasion to discount the results of a method which, though not perhaps precise, is reasonable and justified by observation of actual effects.

Much attention is given to the detailed design of riveted connections and pillar seatings, i.e., those providing a shelf or rest, taking the end reaction of a beam. It may be said that such minute analysis is seldom given in books upon this subject, and it may be read with advantage, if with critical care, as the methods adopted are not uniformly acceptable. In illustration of this may be mentioned the rigid limiting of bearing pressure at a seating to 11 tons per square inch, in the case of packings stressed through their thickness, or of parts in which no harm can possibly result if there is some local over-stress. Such cases are entirely different from pressure on rivet shanks, or on the edges of stiffener fins. A simplified column formula presented, is of interest, as also the examination of excentrically-loaded columns. The same comment is applicable to an investigation into the stresses induced in curved members, or members with axial and transverse loading.

This book may be commended to the attention of all interested in structural design. There is in it a fair amount of original matter, but it should be read with discretion, as the author is not equally happy in his methods throughout the work. What slips there are, and where, the reader is advised to find out for himself. With respect to the arithmetical work there seems to be a commendable freedom from error. The book is well indexed.

STEEL STAGING FOR SHIPBUILDING BERTHS.

THE accompanying engraving illustrates a new form of steel staging for shipbuilding berths, constructed by the Glasgow Steel Roofing Company, Limited, Possil Park, Glasgow, and of more than usual interest in view of the scarcity of imported spars and the difficulty of getting home-grown timber equally suitable. Shipbuilders have felt the need for a suitable substitute for timber for a considerable time, and the design under discussion is the invention of a well-known shipbuilding manager, Mr. George W. MacIlwaine, who has had the benefit of the technical advice and assistance of the

Glasgow Steel Roofing Company, Limited, in finally producing something that makes a decided appeal to the shipbuilding world.

In addition to the use of steel, the designer has achieved a further advantage as the staging is arranged to slide in and out to suit varying widths of ships to be built, and generally to meet the requirements of plating and riveting. It is not necessary, therefore, to remove the staging as is the case with timber uprights when a new ship is laid down. Thus considerable labour is saved.

The staging itself is formed of two channel steel pillars, 45 ft. high, prepared at top for extension pieces 10 ft. in length, and fitted at the ground level into an angle and steel plate base, all rough surfaces being eliminated, so as to avoid wear and tear of ropes. The area of ground on which the pillars are to be used is covered by a thin bed of concrete, reinforced with sheets of expanded metal, and having at surface level two channel steel beams or rails, laid about 4 ft. 6 in. apart, with the top flange protruding just above the surface of the cement. These channels are 10 ft. long, which allows for a sliding movement on both sides of the berth, of 15 ft.; where a greater sliding movement is desired, extra lengths of channels can be laid at any time. The edges of the base of the verticals are slipped in under the upper flange of the channel rails embedded in the concrete, and rest on a flat steel wearing strip. Four flat steel wearing strips are also laid on the top of the concrete. When in position the base is wedged up. When a slight movement is required, the wedges are taken out, and it is found, in practice, that the operation of sliding the pillar along the wearing strips can be readily accomplished. Both in respect of the sliding movement and in the amount of shipyard space between ships that can be saved through the adoption of these pillars, it is claimed that this staging is a great advance on anything at present in use.

In another respect an improvement on ordinary methods has been adopted. Slots are cut in the verticals 2 ft. apart, and through these a small channel section is arranged with a projection of 33 in. to carry three 11-in. planks. This channel section is so designed that when in position it is self-locking and immovable. By a very simple operation it can be taken out and fixed through the next series of slots without the adjustment of a single bolt or nut. These small channel steel thwarts form a most effective landing for the planking proper. They are light and easily handled, and offer no difficulty in the way of speedy removal upwards.

Arrangements have been made by the manufacturers for the standardisation of the staging and for its production in large quantities, and it is intended to be sold at a price that will put wood out of competition when due allowance has been made for the depreciation and loss during re-erection that are associated with the present form of staging in use. The whole is formed of shipyard sections throughout, so that no delay in respect of deliveries need be anticipated.

DOCKING A DOCK.—The floating dock of the Göta yard at Gothenburg, which is the largest in Scandinavia, has just undergone a somewhat peculiar test, inasmuch as the Eriksberg floating dock has been docked in it, and in the Eriksberg dock there was at the time a fairly good-sized tugboat, which remained in the latter dock during its towing to the Göta yard. Both the dock and the tugboat had to be overhauled, and the latter was to undergo a number of repairs, both of which jobs proceeded simultaneously. The Eriksberg dock can accommodate vessels up to 3,200 tons, the Göta yard floating dock being large enough to receive the Swedish America liner Stockholm. The latter dock can dock itself, being so constructed that two parts can dock the third.

DUTCH SHIPBUILDING.—The war has given a very pronounced impetus to Dutch shipbuilding, which will appear from the following figures. In the year 1912 there were only nine yards in Holland which went in for building goodsized vessels, and the following year the number had increased to 13. Then the war came and with it a strong demand for new vessels, more especially from the Scandinavian countries which could no longer obtain any vessels from Great Britain. As a result of this several Dutch yards, which had formerly confined their work to river boats, undertook the building of large sea-going vessels. At the end of 1914, 24 Dutch yards had gone in for this class of work and the number continued to increase at a brisk rate, being 44 in 1915, 69 in 1916 and 109 at the end of 1917. Most of these yards, however, did not build vessels above 2,000 tons gross, or motor vessels of about 500 tons gross. In 1913, the Dutch yards received orders for 55 new vessels, in 1915 for 191, in 1916 for 259 and in 1917 for 340. The increase is fairly evenly divided between large and small steamers and motor vessels. Foreign orders culminated in 1916, the decline being no doubt owing both to shortage of raw materials and the difficulty of giving delivery, when the vessels were ready.

PERSONAL.—Following the death of the late chairman, Mr. Arthur T. Keen, the Earl of Bessborough, K.P., has been elected chairman of Messrs. Guest, Keen and Nettlefolds, Limited, and Mr. F. W. Keen and Mr. Edward Steer, deputy-chairmen. Lieutenant-Colonel the Hon. C. H. C. Guest, M.P., and Mr. H. Probyn, who has held the position of secretary to the company since its formation, have been appointed to seats on the Board. An Executive Committee of General Managers has been formed. Mr. J. H. Jolly, at present secretary of the Blaenavon Company, Limited, has been appointed to the post of secretary and chief accountant.—The directors of the Stanton Ironworks Company, Limited, near Nottingham, state that, subject to the approval of the Treasury, they have entered into a provisional agreement with the directors of the Holwell Iron Company, Limited, of Melton Mowbray, under which the shares of the Holwell Company will be acquired by the Stanton Company. The Stanton Company employs some 7,000 workmen in connection with their blast furnaces and foundries at Stanton, collieries near Mansfield, and ironstone fields in Leicestershire and Northamptonshire. The Holwell Company employs some 1,200 workmen in connection with their blast furnaces and foundries at Melton Mowbray and ironstone fields in Leicestershire and Lincolnshire. The combined companies—Stanton with its nine, and Holwell with its four blast furnaces, and additions now in course of erection—will be the largest producers of pig-iron in the Midlands. Both companies have established a world-wide reputation with gas and water engineers for the high quality of their cast-iron pipes and general castings. In this direction their combined output is far in excess of that of any similar undertaking in this country.

THE EFFECTS OF COLD-WORKING ON THE ELASTIC PROPERTIES OF STEEL.*

By J. A. VAN DEN BROEK, Instructor in Engineering Mechanics, University of Michigan.

Introduction.—Steel has been intensively studied especially during the last thirty years. It would appear, however, that most of the research on steel has been conducted by chemists and metallurgists, and has thus been confined to the chemical and metallurgical laboratory. From the metallurgical and chemical points of view, therefore, the subject of "The Effects of Cold-Working on Steel" has been profoundly studied during the last fifteen years, especially in England, by such men as Beilby, Rosenhain, Ewing and Humphrey. The study of the effects of cold-working on the physical properties of steel, however, seems to be limited to J. Bauschinger,† James Muir,‡ and to the recent work by the United States Testing Laboratory at the Watertown Arsenal, Massachusetts.§ It is stated the tests at the Watertown Arsenal are being continued so that additional information may be expected in the near future.

Bauschinger's work of 1886 to-day stands out pre-eminently as the most advanced treatise on the subject. He experimented mostly on mild steel, and studied the effects of strain in tension and compression on the elastic properties of steel in tension and compression. He also studied the effects of ageing, and to a slight extent the effect of tempering on cold-worked steel.

Muir, who also worked on mild steel, confined himself largely to hysteresis, the effects of cold-stretching, and the effects of tempering at low heats, such as the temperature of boiling water, which he studied in detail.

At the Watertown Arsenal, as stated in its publications to date, experiments with 3·25 per cent. nickel steel were carried out, and the effects of cold-stretching on the elastic properties in tension and compression were studied. Some attention was paid to ageing, but none to tempering.

Commercially, the term cold-working ordinarily refers to cold-drawing, rolling or twisting. In this paper the term will be applied to any process which causes permanent change of shape of steel at a temperature below the critical temperature. An attempt has been made to study the subject in its broadest aspect. Steel has been cold-stretched, cold-compressed and cold-twisted, and each one of these three kinds of cold-working has been studied as to its effects on the elastic properties of steel in tension, compression and torsion. In addition, the effects of tempering cold-worked steel at such low temperatures as the temperature of boiling water have been investigated in connection with ageing.

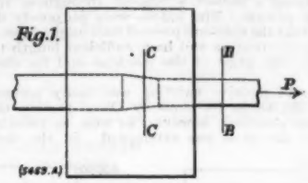


Fig. 1. (5463.A)

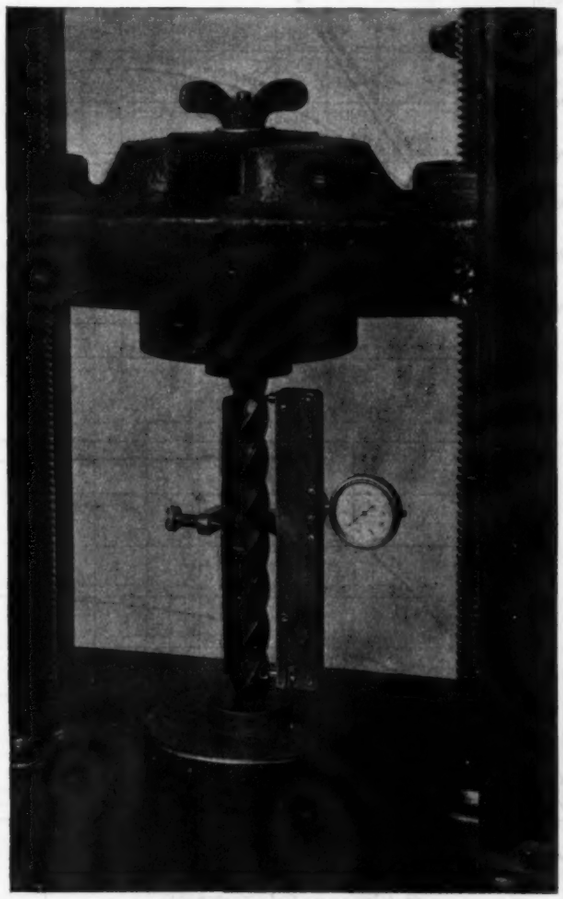
Materials and Apparatus.—The material considered in this paper has been a low carbon, hot-rolled, mild steel. The chemical composition of a few of the bars tested is as follows, different bars being designated by different letters :—

TABLE I.

Letter.	C.	Mn.	Si.	Ni.	Cr.	S.	P.
d	0·21	0·40	trace	nil	nil	0·040	0·012
p	0·16	0·27	...	,,	,,	0·063	0·004
k	0·16	0·26	0·018	,,	,,	0·025	0·006
w	0·26	0·34	0·009	,,	,,	...	0·017
Balls	0·95	0·37	0·27	,,	0·65	0·025	0·025

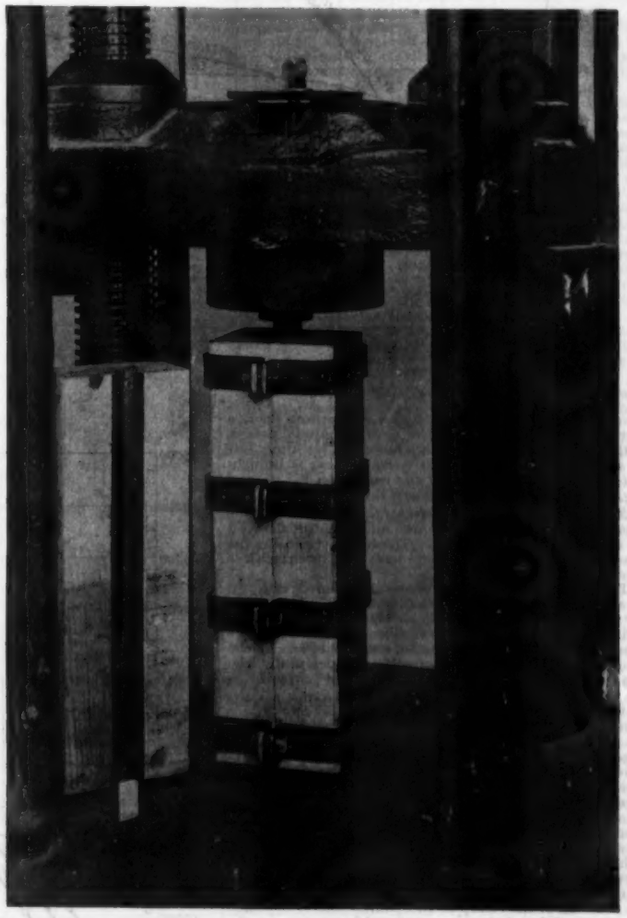
The tests have all been made by the author in the Testing Materials Laboratory of the University of Michigan. The machines used were one 50,000-lb. capacity Riehle tension and compression machine ; one 200,000-lb. capacity Riehle tension and compression machine, and one 232,000-in.-lb. capacity Olsen torsion machine.*

It should be borne in mind that these testing machines are straining machines and not loading machines. Strain is here defined as deformation per unit of length, stress as load per unit of area. For example, in conducting a tensile test, after placing the specimen in the machine, the machine is run at a uniform speed. The specimen is strained (elongated) proportionally to the speed of the machine. At first, within the elastic limit, the stresses increase at the same rate as the strains, and correspondingly the loads, which are measured by the machine, increase uniformly. After passing the elastic limit, although the specimen continues to be strained at the same rate, the stress increments are no longer proportional to the strain increments, and the loads registered by the machine ceases to increase uniformly.



Compression Test Machine with Berry Strain Gauge.

FIG. 2.



Riehle Tension and Compression Machine.

FIG. 3.

Tests.—The tension tests require little explanation. The specimens were tested by the usual method and gripped between wedge grips. For some purposes the threaded grips may be superior to the wedge grips. However, on account of the large variety of specimens tested and the desire to test the same specimens alternately in tension, compression and torsion, it was necessary to use wedge grips, and it was found that, with a reasonable amount of care, the experimental error could be reduced to a minimum.

The compression tests have all been performed on specimens not less than 9½ in. and not more than 20 in. in length. The ends of each compression specimen were faced so as to make them perfectly flat and parallel. Fig. 2 shows a ½-in. square twisted bar in the 50,000-lb. capacity machine ready to be tested in compression.

Possibly some will question the advisability of using such relatively long compression specimens, *i.e.*, for which the ratio l/r is so high. Most experimenters, it seems, have confined themselves, in compression tests, to short columns, sometimes only 1 in. long, presumably to obviate possible errors due to buckling. It appears that one may anticipate two errors in compression tests, one

* Paper read before the Iron and Steel Institute on May 3, 1918.

† Mitteilungen aus dem Mechanisch-Technischen Laboratorium der K. Technischen Hochschule in München, 1886, vol. xiii.

‡ "On the Recovery of Iron from Overstrain," Philosophical Transactions of the Royal Society of London, 1900, vol. cxciii.

§ "Test of Metals," 1915.

* Moore, "Materials of Engineering," page 159.

as the result of buckling and another as the result of friction between the bearing blocks and the ends of the specimen. The latter error, it seems, is nearly always present, and its disturbing effect increases as the length of the test specimen decreases. The effect of buckling, although it plays a very important part in structural columns, it is believed may be neglected in laboratory tests, provided the specimen is carefully prepared and the test carefully performed. When buckling does occur, the error is accumulative and marks the end of the test. Similarly, if one is able to load in compression an unbraced specimen 1 in. square and 20 in. long, to a stress of 80,000 lb. per square inch, as illustrated in curves No. 75(f), Fig. 5, and curve No. 175(m), Fig. 9, and have such specimen support a load of 75,000 lb. indefinitely, one may conclude that the effect of buckling is nil. The horizontal part of curve No. 17(d), Fig. 5, illustrated how a compression specimen

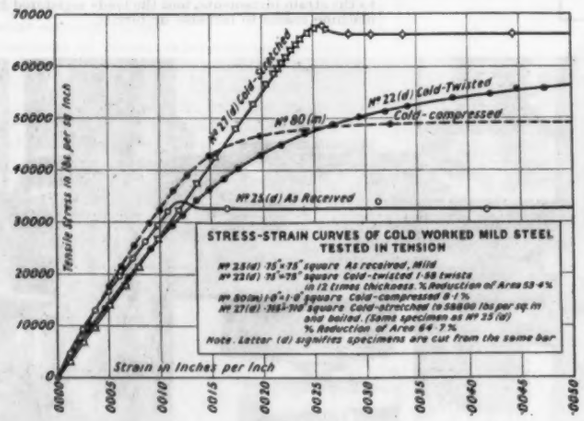

STRESS-STRAIN CURVES OF COLD WORKED MILD STEEL TESTED IN TENSION
Strain in Inches per Inch
Tensile Stress in lbs per sq. Inch
Nº 23(d) Cold-Stretched
Nº 80(m)
Nº 22(d) Cold-Twisted
Cold-compressed
Nº 25(d) As Received

FIG. 4.

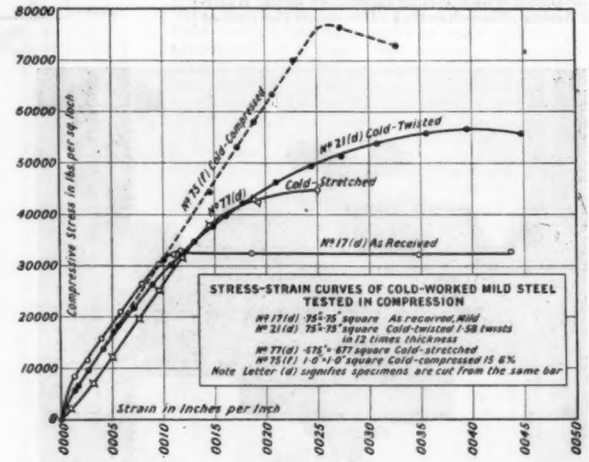

STRESS-STRAIN CURVES OF COLD-WORKED MILD STEEL TESTED IN COMPRESSION
Strain in Inches per Inch
Compressive Stress in lbs. per sq. Inch
Nº 75 (f) Cold-Compressed
Nº 21(d) Cold-Twisted
Nº 77(d)
Cold-Stretched
Nº 17(d) As Received

FIG. 5.

of the bar, after which cold-compressing could be commenced. As the compression progressed the specimen naturally increased in size transversely, but this swelling was easily taken up in the wood and in the steel clamps. After compressing a 22-in. specimen to 21 in. in the 21-in. brace, the load was released, the braces taken off, and the operation repeated in the 20-in. brace. In this manner a bar, 22 in. long, could be shortened 3 in., while maintaining a perfect alignment throughout the cold-working process. The braces were purposely designed long so that the cold-compressed bars might subsequently be tested in tension and have sufficient length to allow space for the grips of the machine and for the strain gauge.

The cold positive twisting was easily accomplished in the 232,000-in.-lb. capacity Olsen torsion machine. Difficulty occurred, however, as soon as twisting in a negative direction was attempted. In the first trial the torsion machine was lifted off its base and the specimen twisted out of alignment, because the machine was not designed to perform negative twisting. By providing a suitable steel framework for the recording end of the torsion machine and weighting it down with a few tons of cast iron, 2 in. diameter round bars were successfully cold-twisted in two directions. Tension and compression may be considered as stresses of the same kind but opposite sign. We might intelligibly distinguish between them as one being a positive stress and the other a negative stress. Similarly, right-handed twisting and left-handed twisting may be considered as of the same kind but opposite sign, and for the purposes of this investigation we shall thus distinguish between positive and negative twisting. However, only a positive torque could be measured on the machine.

Discussion of the Data.—The elastic properties of steel considered in this paper are of three kinds—namely tension, compression and torsion (shear). Four different kinds of cold-worked steel were each tested for these three kinds of elastic properties, namely, steel as received, steel cold-stretched, steel cold-compressed, and steel cold-twisted. Two hundred and fifteen specimens were tested, and curves were plotted for each test. Rather than reproduce over 200 sheets of tabulated data, only curves are here given, and rather than reproduce over 200 curves, many of which are duplicates, only representative curves have been selected and grouped together for purposes of comparison. Of course, curves differed in different tests. Not always, however, have the most nearly perfect curves been selected for reproduction, but rather curves which were to be compared with one another were obtained, as much as possible, from specimens cut from the same bar, and then plotted on the same plate. No curve is here given without having the properties which it suggests substantiated by several independent tests on different material. If some of the stress-strain curves appear usually accurate straight lines, sometimes may be strained, under a constant load, a considerable distance after the elastic limit is passed, without buckling. Ordinarily, however, buckling sets in as soon as the elastic limit is reached, as is brought out by the fact that most of the curves on Fig. 5 and Fig. 8 drop rapidly after the elastic limit is passed.

Measurements.—The angular strains in the torsion tests were measured by an arc and pointer clamped 12 in. apart on the specimen. The linear strains in the tension and compression tests were measured with a Berry strain gauge.

The Berry strain gauge is shown in Fig. 2 clamped to a compression specimen ready for a test. It consists of two steel pivots in a steel frame 8 in. apart. One pivot is fixed while the other is part of a bent lever, and rotates freely in a V-groove. The lever extends inside of the steel frame to a point underneath an Ames dial. The Ames dial registers movement of the end of the lever to $\frac{1}{10,000}$ of an inch. Referring to Fig. 2, the top pivot is fixed while the lower pivot is free to move. As the specimen is compressed the two pivots move closer together, and the lever of which the lower pivot is a part moves outward and reacts on the Ames dial at a point inside the steel frame. Previous to placing the strain gauge, two punch marks are made on the specimen 8 in. apart, with a marker the points of which exactly correspond to the points on the pivots of the strain gauge. In order to avoid bending the specimen as the clamp is tightened, a steel plate, slightly sprung, is slipped between the specimen and the clamp. When the strain gauge is clamped on, this bridge, shown in Fig. 2, carries the reaction of the clamp to two points exactly opposite the pivots of the strain gauge. One objection commonly made to the arrangement as described is that the gauge is clamped to but one side of the specimen. This criticism is no doubt qualitatively justifiable. However, experimental error is inevitable with any instrument. It is merely a question as to whether the experimental error seriously impairs the conclusions drawn from the tests. With careful manipulation it appears that this error dwindles into insignificance. In fact, the curves faithfully plotted from laboratory sheets speak for themselves.

The Cold-Working.—The cold stretching was accomplished in the tension machine by stretching specimens beyond their original elastic limit any desired amount.

The cold-compressing was accomplished in especially designed braces. Fig. 3 shows a 1-in. square specimen in the 200,000-lb. capacity Riehle tension and compression machine, ready to be compressed. One-half of another brace, the one next smaller in size, is depicted to the left in Fig. 3 to show the V-groove and the steel lining of the wooden braces, which proved necessary. A set of braces varying by 1 in. in length from 21 in. down to 16 in. were especially designed for the cold-compression process. If, for example, a cold-compressed specimen was desired long enough after cold-compressing to be used in a tension test, a bar of mild steel 1 in. square, 22 in. long, and with both ends faced, was selected. This specimen was first oiled and then clamped in the 21-in. brace, leaving $\frac{1}{2}$ in. of steel projecting outside of the brace at each end. The clamps were very thoroughly tightened to ensure perfect bearing along the entire length

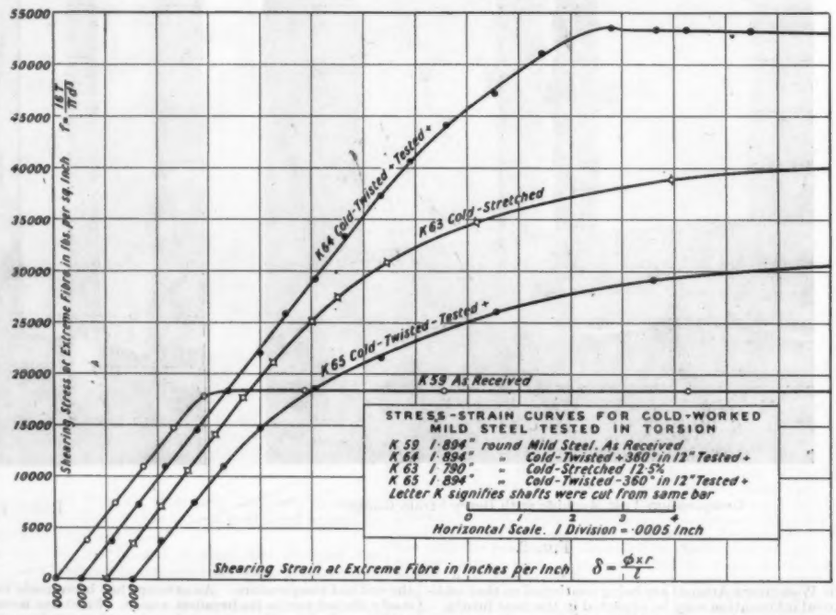

STRESS-STRAIN CURVES FOR COLD-WORKED MILD STEEL TESTED IN TORSION
K 59 1·894" round Mild Steel. As Received
K 64 1·894" " Cold-Twisted +360° in 12" Tested +
K 63 1·790" " Cold-Stretched 12·5%
K 65 1·894" " Cold-Twisted -360° in 12" Tested +
Letter K signifies shafts were cut from same bar
Horizontal Scale. 1 Division = ·0005 Inch
Shearing Strain at Extreme Fibre in Inches per Inch
Shearing Stress at Extreme Fibre in lbs. per sq. Inch
K 64 Cold-Twisted +Tested+
K 63 Cold-Stretched
K 65 Cold-Twisted -Tested+
K 59 As Received

FIG. 6.

they are nevertheless faithful reproductions of laboratory sheets, and it is from the sensitiveness of the curves and the slight deviations from straight lines which one may distinguish, that the author derives his confidence in the significance of the results. As this paper is concerned with the elastic properties of steel, none of the curves are continued to the breaking point. The last point on each curve marks a point well beyond the elastic limit where the strain gauge was removed. Without exception all curves were plotted from the zero point, although the danger of experimental error under low loads, before the test is well under way, is very great. If the specimen is slightly bent, in a tension test, the first increments of load will tend to straighten it, which will cause an erroneous reading of the strain gauge. Possibly the wedge grips do not pull evenly during the first stages of the test, which again may cause an error in strain-gauge reading. In a compression test, the smallest eccentricity in loading, or a minute obstruction between the specimen and the bearing blocks, will cause an erroneous reading

of the strain gauge until an adjustment has been made, after which the strain gauge will record the true elastic behaviour of the specimen. For this reason it is believed best not to attach any special importance to slight positive or negative bends of the curves within low stress values. The essential feature to consider in this discussion would seem to be whether the stress-strain curves beyond stresses of 5,000 lb. per square inch are straight lines or not.

A great deal has been written about the definition of elastic limit and yield-point of steel.* Without presuming to take sides in the different arguments, elastic limit in this paper is understood to be the stress at which the curve first deviates from a straight line. In nearly all cases the point is quite clearly defined on the curves.

By yield-point is meant the stress at which the steel begins to deform very rapidly under very small increments of stress. Although not so clearly defined as the elastic limit, it is nevertheless necessary to refer to it occasionally.

The meaning of the different numbers and letters on different curves is explained as follows. The numbers refer to the order in which the tests were made; the letters in brackets after each number refer to the bar from which the specimen was cut. If the elastic properties of specimens were to be compared with one another, the specimens were, as much as possible, cut from the same bar, and thus, although having a different number, are designated by the same letter in brackets following the number. The curves are to some extent self-explanatory. The type of test they represent is printed on each curve, as much as possible, in order that the diagrams may be studied independently of the text. All curves on each diagram, although representing specimens cold-worked in different manners, represent one kind of test only—namely, tension, compression or torsion. The only exception is in Fig. 12, page 103, where one compression curve is shown along with two tension curves. The diagrams showing tension and compression curves need little explanation. The stress is the load per unit area; the strain is the deformation (lengthening or shortening) per unit of length. The degree of cold-stretching or cold-compressing is expressed in percentage, which was obtained by computing the difference between the original and the final gauge length of the specimen and dividing that difference by the original gauge length.

The slope of stress-strain curves is a measure of the modulus of elasticity, or of rigidity. All curves with the same slope, therefore, have the same modulus of elasticity, or modulus of rigidity. Torsional stress-strain curves are frequently seen plotted with the torque as abscissa and the angle of twist as ordinate. Since the torque varies as the cube of the diameter and the angle of twist varies inversely as the diameter, one naturally obtains in such a case two entirely differently sloping curves for two shafts that are essentially the same and differ only in diameter. The curves in Figs. 6 and 9 are all plotted from data reduced to units corresponding to the units plotted on the tension and compression stress-strain curves—namely, stress at the extreme fibre figured from the formula $f = \frac{16\,T}{\pi\,d^3}$ and strain at the extreme fibre from the formula $\delta = \frac{\phi \times r}{l}$. With these units torsional stress-strain curves will have the same slope when the modulus of rigidity of different specimens is the same, regardless of differences in diameters of the shafts. In an attempt to reduce the degree of cold-twisting to standard units, the degree of cold-twisting of specimens, the stress-strain curves of which are plotted on Fig. 9, is expressed in a percentage as radians of twist per radian of length. Thus a 3-in. shaft twisted 1 revolution in 12 in. would be said to be cold-twisted, $\frac{2\pi \times 1{\cdot}5}{12} = 0{\cdot}787$ radians per radian = 78·7 per cent.

On Figs. 6, 7, 8, 9 and 12 the origin for each curve was shifted so as to avoid overlapping of curves. Figs. 4, 5 and 6 are similar and should be studied in conjunction. Fig. 4 shows steel cold-worked in four different ways and subsequently tested in tension. Fig. 5 shows a similar set of specimens tested in compression, and Fig. 6 shows a third set cold-worked in four different ways but tested in torsion.

Curve No. 25(d), Fig. 4, shows a stress-strain curve for a bar of mild steel "as received," tested in tension. By "as received" is meant the state of the steel in which it was received at the laboratory, viz., hot rolled and covered with mill scale. It may be noticed that the major part of curve No. 25(d) is horizontal until it runs off the plate. This of course does not mean that the steel broke at that point or that the steel could be strained indefinitely without producing any increase of stress. In order to plot curve No. 25(d) to the same scale, until its maximum stress was reached, we should require a diagram ninety times the length of Fig. 4. After the data for curve No. 25(d) were obtained, the strain gauge was removed and the bar was continued to be strained until a maximum stress of 58,800 lb. per square inch was reached. It was then taken out of the machine, boiled for 15 minutes, and tested again as No. 27(d). Note that the elastic limit of No. 27(d) comes at about 66,000 lb. per square inch, or 12 per cent. beyond the stress at which the cold-stretching was discontinued.

Also note the high ductility, 64·7 per cent., as expressed in percentage reduction of area, coincident with this high elastic limit. In fact, the effects of cold-working on the elastic properties of steel seem to be independent of the stresses involved in the cold-working process, but seem to be a function of the strains produced in cold-working, regardless of how such strains are brought about. Curve No. 22(d), Fig. 4, and curve No. 21(d), Fig. 5, were obtained from a piece of steel cut from the same stock as No. 25(d) and No. 27(d), cold-twisted, then cut in two, and one part tested in tension as No. 22(d), Fig. 4, and the other part tested in compression as No. 21(d), Fig. 5. These two curves are very similar indeed, which suggests that cold-twisting modifies the tensile elastic properties of steel similarly to the way it modifies its compressive elastic properties.

Curve No. 75(f), Fig. 5, was obtained from a specimen cold-compressed 15·6 per cent., then boiled, and then tested in compression. It is seen that, just as cold-stretching raises the elastic limit of steel in tension, so cold-compression raises the elastic limit of steel in compression.

Curve No. 80(m), Fig. 4, was obtained from a specimen cold-compressed 8·1 per cent., tempered in boiling water and tested in tension. Curve (77d), Fig. 4, was obtained from a specimen cold-stretched 24·1 per cent., boiled and tested in compression. Both curves show an elastic limit of the same value as the original elastic limit but a somewhat raised yield-point.

Figs. 7, 8 and 9 were compiled for the purpose of bringing out the significance of time and temperature effects on cold-worked steel.

It is seen from curves No. 171(p), No. 78(d), and No. 172(p), Fig. 7, from curves 176(m) and 175(m) Fig. 8, and from curves 182(v) and 183(v), Fig. 9, that if steel is tested in the direction in which it was cold-worked, very soon after cold-working, the elastic limit is lowered below the original elastic limit, often down to zero, and the yield-point comes about at the stress at which cold-working was discontinued. If the specimen is aged for a short time (curve No. 78(d), Fig. 7, the yield-point is raised, but the elasticity is not perfected; if the specimen is tempered, however, at a heat of about 100 deg. C. or more, the elasticity of the steel is perfected and the elastic limit is raised from 10 per cent. to 20 per cent. beyond the stress at which cold-working was discontinued. Curves of aged specimens, other than the one here shown (No. 78(d), Fig. 7), have shown occasionally greater improvement in the elastic properties of steel, as the result of ageing, but never have the effects of ageing 100 days proved equal to the effects of tempering. It is believed, however, that if sufficient time is allowed, ageing will perfect the elasticity of cold-worked steel to the same extent that tempering at low temperature does.

After the diagrams were made up, a possible source for misinterpretation was noticed in the way curves A, No. 171(P), No. 78(d), and No. 172(P) are shown in relation to one another on Fig. 7. It is to be noted that No. 171(P) and No. 172(P) are strictly comparable. They were of the same specimen, in one case tested immediately after cold-working; in the second case tested after tempering for a few minutes at 100 deg. C. Curve No. 78(d) was of an entirely different specimen, and is strictly comparable to curve No. 27(d), Fig. 4. In its position on Fig. 7, it shows clearly that ageing 114 days did not perfect its elasticity beyond its original elastic limit; that is to say, the curve approaches the original tangent but does not coincide with it. It might, however, also lead one to suppose that ageing did not raise the yield-point. This is not the case, as a similar specimen without ageing not only departed further from a straight line, but had its yield-point 10 per cent. lower; and a third specimen, cold-stretched exactly the same amount and boiled, was like curve No. 27(d), Fig. 4, with its curve perfected but its yield-point at about the same value as that reached by ageing 114 days.

On the specimens tested in a direction opposite to the direction of cold-working (curves No. 114(t), 115(t), and 112(t), Fig. 7, curves 180(w), 178(w), and 177(w), Fig. 8, and curves 146(v) and 147(v), Fig. 9), the effect of ageing and tempering is seen to be even

STRESS-STRAIN CURVES OF COLD WORKED MILD STEEL TESTED IN TENSION

Showing the effect of aging & tempering on the elastic properties of cold-worked mild steel.

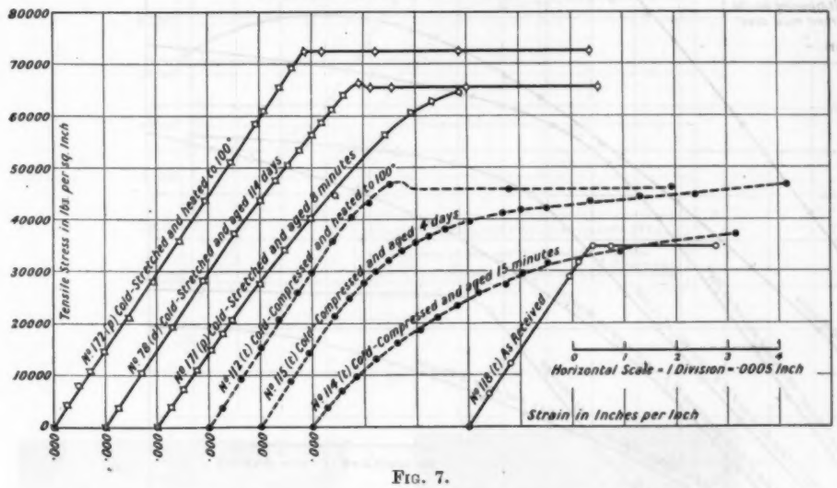

Tensile Stress in lbs per sq inch
80000
70000
60000
50000
40000
30000
20000
10000
0
.000
No 172(p) Cold-Stretched and heated to 100°
No 78 (d) Cold-Stretched and aged 114 days
No 171 (p) Cold-Stretched and aged 8 minutes
No 113 (t) Cold-Compressed and heated to 100°
No 115 (t) Cold-Compressed and aged 4 days
No 114 (t) Cold-Compressed and aged 15 minutes
No 116 (t) As Received
0 1 2 3 4
Horizontal Scale = 1 Division = ·0005 Inch
Strain in Inches per Inch

FIG. 7.

STRESS-STRAIN CURVES OF COLD-WORKED MILD STEEL TESTED IN COMPRESSION

Showing the effect of aging & tempering on the elastic properties of cold-worked mild steel.

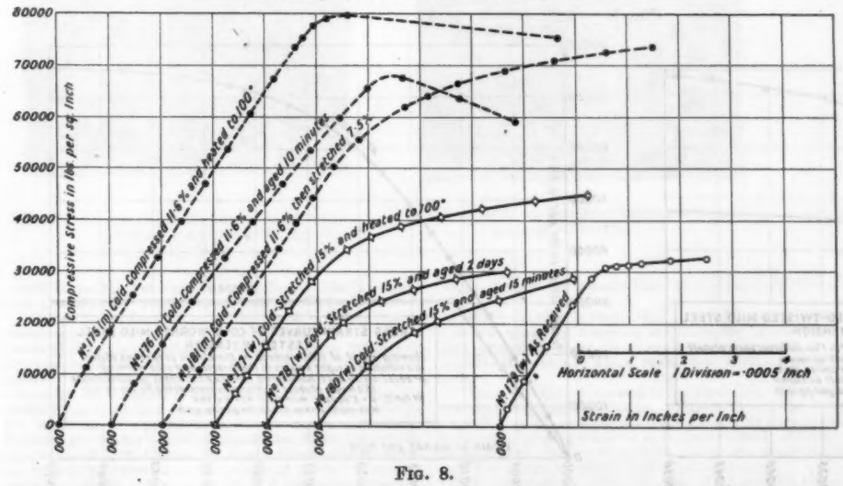

Compressive Stress in lbs per sq. Inch
80000
70000
60000
50000
40000
30000
20000
10000
0
.000
No 175 (m) Cold-Compressed 11·6% and heated to 100°
No 176 (m) Cold-Compressed 11·6% and aged 10 minutes
No 181 (m) Cold-Compressed 11·6% then stretched 7·5%
No 177 (w) Cold-Stretched 15% and Heated to 100°
No 178 (w) Cold-Stretched 15% and aged 2 days
No 180 (w) Cold-Stretched 15% and aged 15 minutes
No 179 (w) As Received
0 1 2 3 4
Horizontal Scale 1 Division = ·0005 Inch
Strain in Inches per Inch

FIG. 8.

* Howard and Linch, Proceedings of the American Society for Testing Materials, 1915–16.

more pronounced. When a specimen is tested within 10 minutes after cold-working, in a direction opposite to that in which it was cold-worked, the elastic limit is seen to be zero (curves 114(t), Fig. 7, 180(w), Fig. 8, and (146v), Fig. 9). If aged for a few days, the elasticity is partly restored, but in no case comes up to the original elastic limit (curves No. 115(t), Fig. 7, and No. 178(w), Fig. 8). If heated to 100 deg. C. or a little more, the elasticity of the specimen is perfected up to or somewhat above the original elastic limit (curves No. 80 (m), Fig. 4, No. 77(d), Fig. 5, No. K.65, Fig. 6, No. 112(t), Fig. 7, No. 177(w), Fig. 8, and No. 147(v), Fig. 9).

Curve No. 181(m), Fig. 8, shows the elastic properties of steel which was cold compressed 11·6 per cent., then boiled, then cold stretched 7·5 per cent., then boiled and subsequently tested in compression.

The horizontal portion of the stress-strain curves, so pronounced in many of the curves, may be explained as follows. The engineer defines elastic limit as the stress at which the stress-strain curve departs from a straight line. The metallurgist defines it as the stress at which some of the steel grains begin to break up (grain failure along slip bands). The two values exactly coincide. The breaking up of the crystals, however, requires time and energy. In a bar machined down in the middle it usually begins in the centre. In a bar of mild steel gripped in wedge grips, it always begins between the wedges, because the strain conditions at that point are a maximum, being the result of the combination of high compression stresses, due to the wedge grips, and high tensile stresses, due to the machine loading. If the straining (elongating) of the specimen continues uniformly the rupturing of the crystals progresses from the centre towards the ends, or in case of wedge grip arrangement, from the ends towards the centre, under a uniform stress, until all the crystals throughout the entire length of the bar are ruptured, after which the stresses will increase again, more or less proportionally to the rate of increase of the strains. It should be remembered that the modern testing machine is a straining machine and not a stressing machine.

When a bar of mild steel is strained sufficiently to start some of the crystals rupturing and the machine is then stopped, the specimen will come to equilibrium under a stress such that a little more stress will result in more crystals rupturing; a continuation of that stress or any value less than that stress will leave the specimen in a state with some of its crystal grains ruptured, while others are still intact. This process might be likened somewhat to a line of dominoes set on end. One is caused to fall against an adjoining one, and the whole line will fall as long as conditions are kept constant. When steel is strained and crystals begin to break up, one crystal which fails diverts more stress to its neighbour, this adjoining crystal breaks and in turn causes the next one to break, provided the stresses are kept constant. In the ordinary testing machine, however, the stress cannot easily be kept constant under such conditions. Therefore, when the machine is stopped after the yield-point of the specimen is passed, the crystals keep on rupturing for a short time, the specimen correspondingly elongates a little and the load correspondingly drops slightly. The load to which the machine settles down after a specimen of mild steel has been stressed slightly beyond the yield-point, but before the crystal grains are disturbed throughout the entire length of the bar, the author has found, corresponds exactly to the elastic limit. If the specimen is being elongated uniformly and continuously, the horizontal part of the curve will run a little higher than if the machine is stopped at intervals and readings taken when the interior of the bar has reached a stage of equilibrium. This is easily explained by the fact that it requires a greater stress to rupture crystals throughout the length of the specimen at a rapid rate than it does at a slow rate.*

Cold-Stretching Steel does not Lower its Elastic Limit in Compression.—In nearly all the literature of the last twenty years on the effect of overstrain on steel, the statement occurs that cold-stretching, although raising the elastic limit in tension, lowers the elastic limit in compression.

Rosenhain, one of the most enthusiastic exponents of Beilby's amorphous cement theory, writes in his introduction to "Physical Metallurgy," Van Nostrand Company, 1914, page 247:—

"There is one difficulty about the explanation of the hardening of metal by plastic strain, as given by the conceptions explained above, which requires brief mention. This lies in the fact that the hardening produced by plastic strain is, in certain cases at all events, unidirectional. For instance, a piece of steel which has

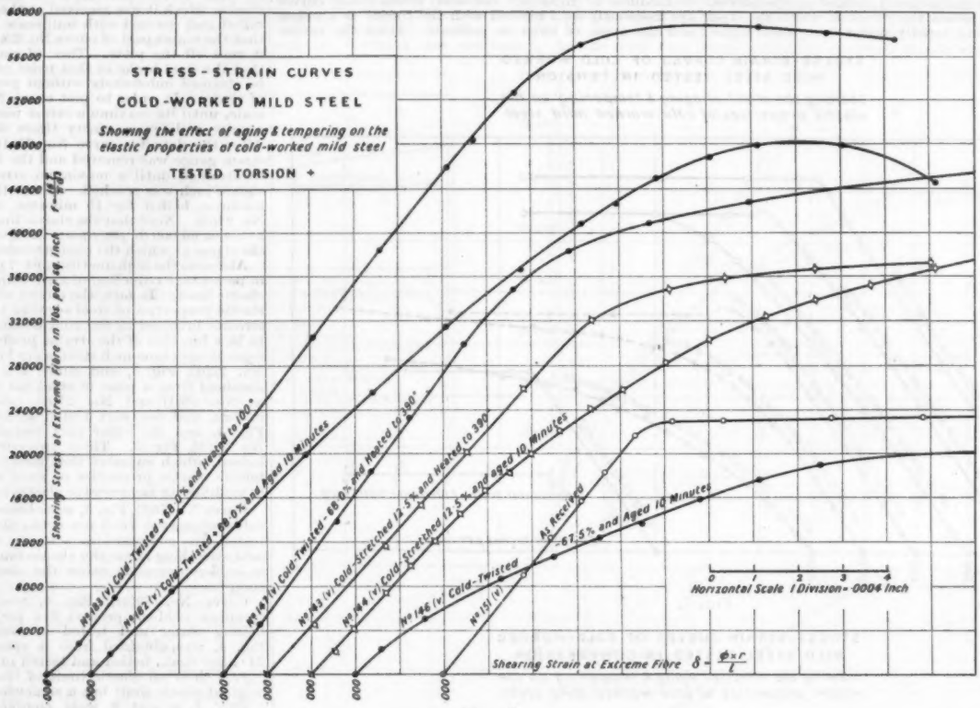

STRESS-STRAIN CURVES
OF
COLD-WORKED MILD STEEL
Showing the effect of aging & tempering on the elastic properties of cold-worked mild steel
TESTED TORSION +
Shearing Stress at Extreme Fibre in lbs per sq inch
Shearing Strain at Extreme Fibre
Horizontal Scale 1 Division = 0004 inch
As Received
Aged 10 Minutes
Heated to 390°

FIG. 9.

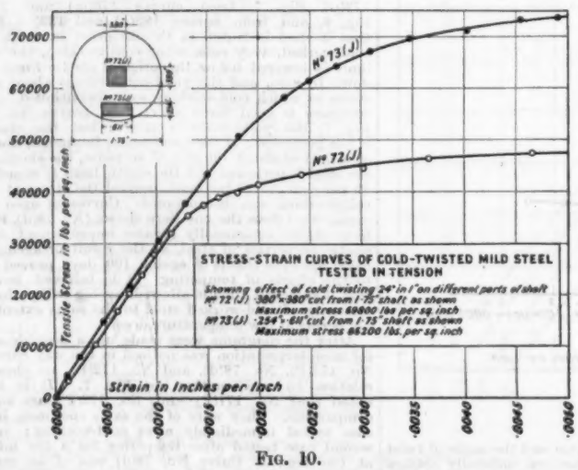

STRESS-STRAIN CURVES OF COLD-TWISTED MILD STEEL TESTED IN TENSION
Tensile Stress in lbs per sq inch
Strain in Inches per Inch

FIG. 10.

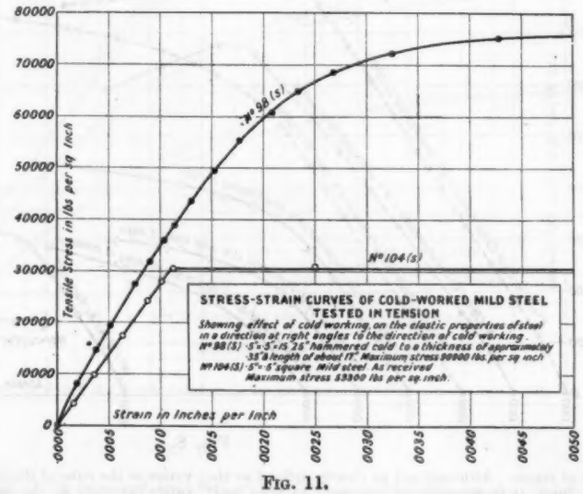

STRESS-STRAIN CURVES OF COLD-WORKED MILD STEEL TESTED IN TENSION
Tensile Stress in lbs per sq inch
Strain in Inches per Inch

FIG. 11.

* For beautiful photographs illustrating this point, see "Commission des Methodes d'Essai des Materiaux de Construction, Rapports Particuliers," tome ii, 1900.

been 'hardened,' i.e., has attained a raised yield-point and apparently raised elastic limit, as the result of tensile overstrain, is not really hardened in every way, for, if it is tested in compression, it is found that for stresses of that kind the apparent elastic limit has been lowered, so that the total range of stress of elasticity, from the limit in compression to the limit in tension, has not been materially altered. It is difficult to see how the formation of hard amorphous layers on surfaces of slip can account for softening of the metal in relation to compression while producing hardening as against tension. It may be, of course, that there is something directional about the manner in which the crystalline arrangement is broken up on the slip surfaces, so that a configuration results which allows of slip in one direction but not in another."

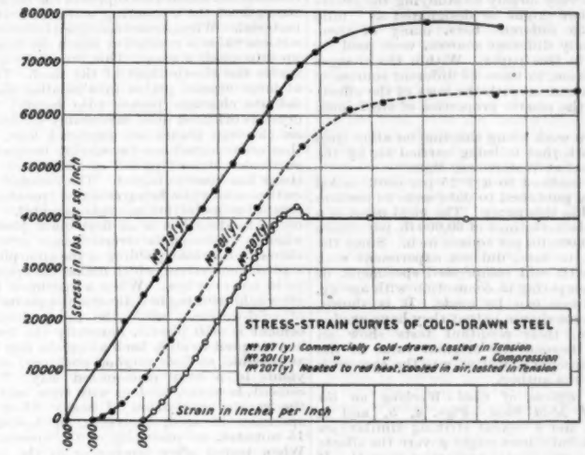


FIG. 12.

And James Muir writes in his article on "The Recovery from Overstrain," Phil. Trans., vol. cxciii, page 45 :—

"Curve No. 4, further, very clearly shows that tensile overstrain—which raises the yield-point in tension—lowers that in compression, or, it may be more definite to say, lowers the load at which any arbitrary contraction occurs. This is in agreement with Professor Bauschingers conclusion with regard to the elastic limits, viz., that the elastic limit in tension cannot be raised without lowering the limit in compression and *vice versa*. Professor Bauschinger draws a further conclusion from his experiments, namely, that when the elastic limits of a material are varied by overstrain, the range of perfect elasticity seems to remain constant, so that, if the elastic limit in tension be raised, then that in compression is lowered by an equal amount. The author's experiments do not bear this out."

Muir attributes here to Bauschinger the claim that, as the result of tensile overstrain, the elastic limit of steel in compression is lowered an amount equal to the amount its elastic limit in tension is raised, maintaining constant what is called the elastic range. Although other writers on this subject for the last twenty years almost invariably make this statement, it is usually not accompanied by references to its source, and possibly they are mostly quoting Muir's interpretation of Bauschinger's results."

The author, upon studying Bauschinger's data, was unable to find any such statements. On page 19, statement 2, of Mitt. aus dem Mech. Tech. Laboratorium der K. Technischen Hochschule in München of 1886, Bauschinger states the results of his experiments on the effect of stretching on the elastic properties of steel in tension as follows :—

"The elastic limit (in tension) is lowered as the result of stretching, often down to zero, so that the specimen, when it is tested immediately after cold-stretching, has no, or else a very much reduced, elastic limit. During the period of rest which follows the cold-stretching, however, the elastic limit increases again. After several days it attains the stress with which it was cold-stretched, and after a sufficiently long period, certainly after many years, it increases to a value even higher than this stress."

On page 33 of the same article he says with reference to the elastic properties in a direction opposite to the direction of cold-working :—

"As the result of stressing in tension or compression beyond the elastic limit, the elastic limit in compression or tension, respectively, is considerably lowered, so much the more, if the cold-working stresses exceed the respective elastic limits by larger amounts and even comparatively small increments of stress beyond the elastic limits, reduce the elastic limit in opposite direction to zero.

"When an elastic limit, thus lowered in one direction, is raised again by stressing in that same direction, and then exceeded, then, at once, the elastic limit in the opposite direction is again reduced to zero, or nearly to zero.

"Time in these processes is without any effect, or at least has very slight influence. That is to say, the elastic limit in tension or compression, lowered by compression or tension, respectively, is not again raised, at least in the course of three or four days, and in the course of the next few weeks certainly only a little, if at all."

It is interesting that this law of Bauschinger's laid down in 1886, is essentially confirmed by all subsequent research, and also by the work presented in this paper. The generally quoted statement that stretching steel lowers its elastic limit in compression proportionately to the amount it was stretched beyond its original elastic limit, is therefore not substantiated, neither by Bauschinger, nor by Muir, nor by the author, and the author has failed to discover any original data anywhere which seem to substantiate that contention. The apparent discrepancy between the results of different authors seems to be due to the fact that the significance of ageing and tempering has not always been sufficiently emphasised. Bauschinger states that ageing perfects the elastic properties in the direction of cold-working very soon. Scrutinising Bauschinger's and Muir's original data, it does not appear that with ageing they have ever reached a perfect elasticity in the direction in which the specimen was cold-worked, although the deviation from a straight line stress-strain curve was so little that they possibly disregarded it. As regards specimens which were cold stretched and subsequently tested in compression, the same law of ageing seems to hold, only the variations are much more marked. In either case, tension or compression, ageing or tempering, has the tendency to perfect the elastic properties of cold-stretched steel; however, while as regards tension, the stress-strain curve may in a few weeks become so nearly a straight line that it requires a very sensitive test to detect any lack of elasticity, as regards the compressive elastic properties, the amount of improvement necessary to reach perfect elasticity is so large that any shortcoming in it is inevitably detected.

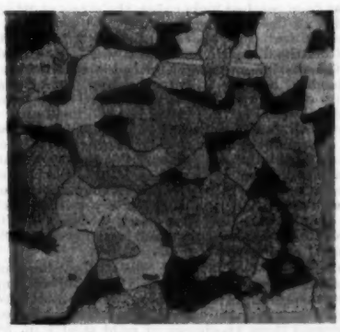
In these experiments, everything seemed to point to the fact that tempering at low temperatures was equivalent to accelerating the effects of time. Because time was lacking to allow specimens to age properly, curves on Fig. 12 were obtained from a commercially cold-drawn specimen.

By studying the records of the engineering shops of the University of Michigan, the author obtained a piece of ½-in. round steel, commercially called cold-rolled shafting, which was received at least six months ago. It appears safe to consider this stock is cold-drawn, although the trade name may be cold-rolled. It is believed cold-rolling is rarely used except for stock over 3 in. diameter, and certainly not for stock as small as ½ in. diameter.

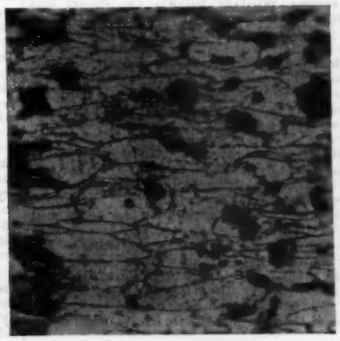
One specimen cut from this bar was heated to a red heat and allowed to cool in the air in order to obtain a state of metal corresponding to a hot-rolled bar. Curve No. 207(y) gives the stress-strain curve for this specimen. Curve No. 197(y) gives the stress-strain curve of the cold-drawn and aged steel as it was when the author obtained it, tested in tension, and curve No. 201(y) gives the stress-strain curve of a similar specimen tested in compression. It may be noticed how the elastic limit in compression, if anything, is a little above the original elastic limit.

[Muir, in a paragraph quoted above, incidentally gives results at variance with the results given here. It would seem, however, that his tests on elastic properties are inconclusive because, on the one hand, they were limited in number, and on the other hand the specimens were only 1½ in. long—that is, too small for accurate work.

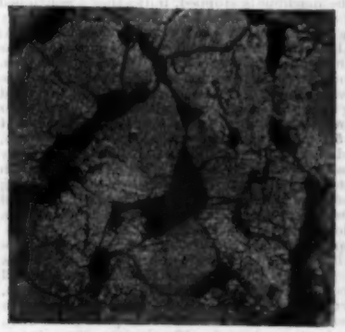
If the contentions set forth in this paper are correct, it would appear that the strongest evidence Rosenhain mentions against the validity of his favourite amorphous cement theory is invalid, and Beilby's amorphous cement theory emerges better substantiated than ever.*



No. 1.—Longitudinal section of mild steel specimen used in specific gravity test, "as received"



No. 2.—Same steel, cold compressed to half its original length.



No. 3.—Transverse section of same specimen, cold compressed.

All magnified 600 diameters, and reduced by one-third.

The Effects on Elasticity of Cold-Twisting are Proportional to the Distance from the Axis.—On Fig. 3, curve No. 22(d) has the appearance of being approximately a mean between curves No. 25(d) and No. 27(d), and on Fig. 4, curve No. 21(d), appears to be an average between curves No. 17(d) and No. 75(f). The natural explanation seems to be that in cold-twisting the outside of the bar is strained severely, and the effect of it on the elastic properties corresponds to curve No. 27(d), while at the centre of the bar the material is strained very slightly, and therefore its elastic properties remain approximately as shown by No. 25(d). When a twisted bar is tested in tension, since its elastic properties vary from the centre to the outside, as from curve No. 25(d) to curve No. 27(d), the resulting curve will be a compromise between the two. If the amount of steel similarly strained was also directly proportional to the distance from the axis, a straight line curve could be expected for the tensile stress-strain curve of a cold-twisted bar. Since, however, the cross-sectional area of steel similarly strained varies as the square of the distance from the axis of the shaft, the curve to be expected is a second degree curve, which is borne out by the experiment. The curves in Fig. 10 were obtained to throw some light on this hypothesis. A 1¼-in. round bar was cold-twisted 31·5 per cent. A specimen, No. 72(j), was cut from the centre, and another specimen, No. 73(j), was cut from the outside, of dimensions as shown on Fig. 10. The elastic limit of both specimens occurs at the same value as that of the original bar. Note that curve No. 73(j) runs not

* For a more detailed discussion of Beilby's amorphous cement theory, see page 104 of this paper.

only higher than curve No. 72(j), but that the breaking stress of specimen No. 73(j) is 86,200 lb. per square inch, while the breaking stress of curve No. 72(j) is 69,800 lb. per square inch.

The Effects of Cold-Working on the Elastic Properties of Steel are probably a Function of the Strains and Independent of the Stresses involved in the Cold-Working Process.—The interesting point as to whether the effects of cold-working, here discussed, are dependent on the stresses involved in the cold-working of the steel or are determined by the degree of deformation given to the specimen as the result of cold-working, cannot be fully determined from the results of this investigation. It seems certain, however, that the stresses set up in cold-working have little to do with the changes in elastic properties, and it seems likely that changes in elastic properties of steel are determined by the degree and kind of deformation given to the specimen in the process of cold-working, regardless of what stresses were involved in bringing these deformations about.

Fig. 11 is intended to show the effects of cold-working on the elastic properties of steel in a direction at right angles to the direction of cold-working. Curve No. 104(s) shows the stress-strain curve of the steel as received. Curve No. 98(s) shows the stress-strain curve of a specimen cut from the same bar and hammered cold transversely, in a steam trip hammer, subsequently machined, and then tested in the direction of the longitudinal axis of the specimen. The stresses in the direction of the longitudinal axis of specimen No. 98(s) at no time during the cold hammering process, can have been tensile stresses. The elongative strains, however, in the direction of the longitudinal axis amount to approximately 11·5 per cent. It is seen that cold hammering at right angles to the axis produces effects on the elastic properties of steel in a direction parallel to the axis similar to those obtained by straining under pure tensile stresses. That the curve is not a perfectly straight line was to be expected, since the cold hammering effect, of necessity, differed in intensity throughout the specimen. With strains produced, therefore, which correspond to tensile strains, but unaccompanied by tensile stresses, the change of elastic properties corresponds to those produced by cold-stretching.

To determine whether the cold-working strains or cold-working stresses determine the ultimate elastic properties of cold-worked steel another test was made as follows. It is very noticeable that when a specimen of mild steel is stressed beyond the elastic limit, any amount up to the maximum stress, the beam drops as soon as the machine is stopped, indicating a continued rupturing of crystal grains under constant or slightly decreasing stresses. For example, when specimen (A) of original elastic limit of 32,000 lb. per square inch was stressed instantaneously to 58,500 lb. per square inch, it was found to have been strained 9·4 per cent. The machine was stopped and the beam immediately dropped indicating that the specimen continued straining under a decreasing load. If it is desired to maintain a constant stress of 58,500 lb. per square inch on the specimen, it is found that the machine must be slowly turned by hand for several hours to keep the beam balanced with a constant load reading. This indicates that straining of the specimen continues for several hours if the steel is once stressed past the elastic limit and kept under a constant load.

Three specimens, A, B and C, of the same bar were prepared. The original elastic limit of the steel was 32,000 lb. per square inch. Specimen A was stressed instantaneously to a stress of 58,500 lb. per square inch, and found to have been strained 9·4 per cent. Specimen B was stressed to a stress of 58,500 lb. per square inch, this stress kept constant for 50 minutes, when it was found to have been strained 12 per cent. Specimen C was stressed instantaneously to a stress of 61,000 lb. per square inch and found to have been strained 12 per cent. Specimens A and B were thus stressed the same amount, but strained differently. Specimens B and C were strained the same amount but stressed differently. The three specimens were boiled together and then tested in tension. Specimen A was found to have an elastic limit of 64,000 lb. per square inch, specimen B had an elastic limit of 67,000 lb. per square inch, while specimen C had an elastic limit of 67,000 lb. per square inch. Since specimens B and C, which were strained the same amount but stressed differently, had the same ultimate elastic limit, and specimens A and B, which were stressed the same amount and strained differently had different elastic limits, it appears that the effect of cold-working on the elastic properties of the steel is a function of the strain and not of the stress.

Curves on Fig. 10 also indicate a raising of tensile or compressive elastic properties as the result of cold-twisting, without the presence of either tensile or compressive stresses in the direction of the axis of the specimen during the cold-working process.

Fatigue.—Although no fatigue tests were made in this investigation, it may still be proper to call attention to the relation of the curves on Figs. 7, 8, and 9 to the problem of fatigue. A great many tests have been made on steel subjected to repeated stresses in one direction, and also with repeated stresses in opposite direction. Although all experiments agree in that steel fails under lower stresses when the stresses are repeated or reversed a great many times, some differ as to whether steel can be made to fail, even under reversed stresses, at stresses below the original elastic limit. Possibly the difficulty in measuring the stresses or the neglect to consider the rate at which stress travels, may account for some differences of opinion. It is believed the curves on Figs. 7, 8, and 9 are the first to show accurately how the elastic properties of steel are affected under reversal of stresses within a comparatively short time after the steel has been stressed beyond the elastic limit.

Electric Resistivity of Cold-Worked Steel.—Four specimens cut from a hot-rolled mild steel bar, the chemical composition of which is given under (w) in Table I, page 99, were cold-worked and subsequently tested for their electric resistivity by Professor Edward D. Campbell, of the University of Michigan. The first specimen was tested "as received"; the second specimen was cold-strained 15 per cent. and incidentally stressed to a stress of 57,000 lb. per square inch; the third specimen was cold-compressed 10 per cent., and the fourth specimen was cold-twisted 40 deg. in 1 in. The electric resistivity for all four specimens was 13·87 microhms at 25 deg. C., indicating that cold-working does not affect in any way the electric resistivity of steel.*

The Effects of Cold-Working on the Elastic Properties of Alloy Steels.—Bauschinger, Muir and the author confined themselves very largely to studying the effects of overstrain on what might be designated as "mild steel." However, 25 different bars, many of them obtained from entirely different sources, were used for the tests discussed in this paper. Within the changes in chemical composition, in these 25 different sources of test specimens, no variance with the laws of the effects of cold-working on the elastic properties of steel could be detected.

The only extensive work along this line on alloy steel seems to be the work that is being carried on by the United States Arsenal at Watertown, Mass.*

These tests were confined to a 3·25 per cent. nickel steel, and the results published to date seem to confirm the results presented in this paper. The yield-point of a steel with an original elastic limit of 60,000 lb. per square inch is raised to 120,000 lb. per square inch. Since the Watertown Arsenal, to date, did not experiment with torsional tests or with cold compressed specimens, or with the effects of tempering in connection with ageing, no further comparisons can be made. It is shown, however, that to the maximum extent they have aged—namely, seven days, their resultant tests show an imperfect elasticity beyond the original value of the elastic limit of the specimen, just as was the case with specimens tested by the author.

Law defining the Effects of Cold-Working on the Elastic Properties of Mild Steel.—Figs. 4, 5, and 6, and also Figs. 7, 8, and 9 reveal striking similarities which suggest that definite laws might govern the effects of cold-working upon the elastic properties of steel. If we distinguish the several kinds of elasticity and cold-working as being of different direction and sense, for example, tension and compression as of the same direction but opposite sense; positive torsion (+ shear) and negative torsion (− shear) as of one direction but opposite sense; but torsion (shear) and tension, respectively, as being of different direction, then we may say:—

1. When mild steel is cold-worked and properly aged or tempered and subsequently tested in the same sense as that of the cold-working, its elastic limit may be raised more than 100 per cent. and from 10 per cent. to 20 per cent. beyond the stress at which cold-working was discontinued.

2. When mild steel is cold-worked in one direction and properly aged or tempered, but tested in either one of two senses of a different direction, then its elastic limit may be raised some 50 per cent.

3. When mild steel is cold-worked in one sense and properly aged or tempered but tested in the opposite sense, then the elastic limit remains at the value of the original elastic limit, but the yield-point is raised.

4. When mild steel is cold-worked in any direction or sense and tested in any direction or sense, without any ageing or tempering, then the elastic limit falls below the value of the original elastic limit, often down to zero.

5. Tempering cold-worked steel at temperatures from 100 deg. to 300 deg. C., or ageing cold-worked steel, has a tendency to perfect its elastic properties. Tempering merely accelerates the effects of time.

The first part of this statement is exemplified by curves No. 25(d) and No. 27(d), Fig. 4, curves No. 17(d) and No. 75(f), Fig. 5, and curves K 59 and K 64, Fig. 6, and by similar curves on Figs. 7, 8 and 9. The second part of the above statement is exemplified by curve K 63, Fig. 6, curve No. 143(v), Fig. 9, and curve No. 73(j), Fig. 10. The third part of the above statement is exemplified by curve No. 80(m), Fig. 4, curve No. 77(d), Fig. 5, and curve No. K 65, Fig. 6, No. 112(t), Fig. 7, No. 177(w), Fig. 8, and No. 147(v), Fig. 10. The fourth part of the above statement is exemplified by curves No. 114(t), Fig. 7, No. 180(w), Fig. 8, and No. 146(v), Fig. 9.

Theory Explaining the Effect of Cold-Working on the Elastic Properties of Steel.—It is hardly the purpose, in this paper, to review exhaustively the contributions to chemical and metallurgical science, of the last twenty years, bearing on the problem of cold-working steel. Certainly, however, to some, the striking improvements in steel as the result of cold-working appear mysterious. One is likely to presuppose that straining steel beyond the elastic limit injures steel permanently. It may not be amiss, then, to review briefly one of the theories advanced to explain the phenomena associated with cold-working of steel.

The amorphous cement theory was advanced by Beilby about 1903 and developed since, particularly by himself, Rosenhain and Ewing. The following discussion and interpretation of it is made in the light of the facts established in this research.

Beilby and Rosenhain suppose that steel exists in two phases—the amorphous phase and the crystalline phase. As steel crystallises, the size of the crystals is inversely proportional to the rate of cooling. Different crystals are differently oriented, and when they come together, some steel, encased between them, is unable to align itself with either one of the adjoining crystals. This steel remains in the amorphous state and cements the different crystals into one solid mass. This amorphous cement is supposed to be stronger than the crystalline steel. With a rapid rate of cooling the crystals are smaller, the amorphous cement, which coats all the crystal grains, is naturally greater in quantity and, as is well known, the elastic limit of rapidly cooled mild steel is higher than that of annealed mild steel. It has been shown that when steel is fractured the fracture takes place across a crystal and never along one of the crystal boundaries, which also supports the belief in the superior strength of the cementing material over the crystalline material. When a steel specimen is stressed increasingly, a stress value is reached at which the large crystals break up into smaller ones. This breaking up of the crystals marks the elastic limit of the steel. This breaking up of large crystal grains into smaller ones occurs along definite cleavage planes (slip bands). Naturally, the crystals oriented most favourably for breaking up along its cleavage planes are ruptured first, while the ones that are oriented less favourably to the direction of the particular stress applied are ruptured later when the stress has become higher. The internal work expended on the metal while being strained transforms some of the crystalline metal into amorphous metal. This amorphous metal hardens but is at first quite plastic. Therefore, when a specimen is stressed soon after cold-working, there is a constant yielding of the amorphous metal under a permanent stress, which makes the specimen as a whole yield more or less. When a specimen is stressed soon after cold-working in a direction opposite to the direction of cold-working, while the newly formed amorphous cement is still plastic, naturally the fractured crystals are tempted to slide back along the slip bands, as much as possible, to their original positions, and the specimen yields in a very pronounced way. This amorphous cement, however, hardens with time, and especially with the gentle application of heat. After a cold-worked specimen is aged, therefore, or boiled in water for 15 minutes, no plasticity of the specimen is observed. When tested after tempering in the same sense and direction as that of cold-working, most of the planes of weakness have yielded under the cold-working process and renewed breaking up of crystals does not commence, or in other words, the elastic limit is not reached until a stress has been reached higher than the stress at which cold-working of the specimen was discontinued. When a specimen is tested in the same sense but opposite direction from the direction in which it was cold-worked, but after the amorphous cement formed in cold-working has thoroughly hardened by tempering or ageing, breaking up of the crystals does not commence; or in other words, the elastic limit is not reached until after a stress equal to the original elastic limit has been exceeded.

Beilby, Rosenhain and Ewing advance a great deal of chemical and metallurgical data in support of this theory that steel exists in two phases—amorphous and crystalline. One of the facts advanced is that amorphous steel has a lower specific gravity than crystalline steel, and that therefore cold-worked steel, because of its higher percentage of amorphous steel, has a lower specific gravity than "as received" steel.

Microstructure of Cold-Worked Steel.—Regardless of the conclusions drawn from it, the fact that cold-working steel lowers its specific gravity has been well substantiated by independent investigators.* The author, also, has cold-compressed three specimens of mild steel 1 in. by 2 in., and three specimens of tool steel ¾ in. by 1¼ in. to one-half their length, and found a reduction of specific gravity in each case, the average for the six specimens amounting to 0·225 per cent. Photograph No. 1, page 103, gives a photomicrograph of the longitudinal section of one of the specimens of mild steel used in the specific gravity test "as received." Photograph No. 2 gives a photomicrograph of a longitudinal section of the same specimen "cold-compressed" to half its original length. Photograph No. 3 gives a photomicrograph of a transverse section of the same specimen cold-compressed and taken as near as possible to the point in the specimen where No. 2 was taken. The magnification of all three micrographs was 600 diameters.

It may be noticed on No. 2 how the individual grains have flattened as the result of compression, and correspondingly it may be seen on No. 3 of the transverse section, taken at the same point, how these same grains have spread. The actual breaking up of these crystals into smaller parts cannot be determined from these photographs. The rupturing of steel grains under stress along slip bands can be observed under the microscope when the specimen is prepared and polished in advance of the test and the specimen strained subsequently,† and under favourable circumstances it may be observed with the naked eye.‡ The fractures indicated by the slip bands are covered over if the specimen is polished after being strained, and they are too minute to be detected by the microscope upon subsequent etching of a polished specimen.

Tests on Steel Balls.—Another argument for the existence of amorphous steel was advanced by Beilby and Bengough, in explaining the phenomena of polishing

* For a more detailed discussion of this test by Professor Edward D. Campbell, see Faraday Society of 1918; also articles on "Specific Resistance," Journal of the Iron and Steel Institute, 1915 and 1916.

† "Test of Metals," 1915.

* F. C. Lea and W. Norman Thomas, "Change of Density of Mild Steel strained by Compression Beyond the Yield-Point," ENGINEERING, July 2, 1915.

† Ewing and Rosenhain, Philosophical Transactions of the Royal Society, 353A, 1900.

‡ "Commission des Méthodes d'Essai des Matériaux de Construction, Rapports Particuliers," tome ii, 1900.

steel by the formation of an amorphous cement on the surface of a steel specimen while being polished. Polishing steel consists of successive stages of grinding and scratching with an abrasive that is harder than steel. The ultimate result is a mirror face that even under a strong microscope does not reveal any scratches. Sometimes after slight etching with a dilute acid, when some of the outside steel has been removed, scratches may be observed again, indicating that they were merely covered over with something. This something, according to Beilby, Bengough and others is amorphous steel worked up on the surface of the steel by the cold-grinding.

When first produced this amorphous steel is like a viscous liquid. It has a considerable surface tension which causes it to smooth out and even cover minute scratches or cracks. It acts similarly to a band of fresh paint. Just after removal of the brush the marks of the hairs are visible, but in a few seconds surface tension in the fresh paint has caused the ridges to disappear and the paint to present a flat surface. This would thus explain the apparently anomalous fact that successive grinding operations on steel produce a surface which, even under a strong microscope, is free from any abrasive marks. The polishing is thus a cold-working operation, the effect of which does not extend beyond the surface.

Because this amorphous steel produced on the surface by cold-grinding and polishing is stronger and harder than the crystalline steel in the body of the specimen, it occurred to the author that cold-ground and highly-polished steel balls may exhibit differences in crushing strength when tested before and after polishing, or after amorphous cement is artificially removed by acid. The author is at present engaged upon a series of tests on steel balls, generously furnished by the Hoover Steel Ball Company of Ann Arbor, Michigan, the results of which it is hoped will be ready for publication soon. Although too early to discuss these tests here in detail, for the purpose of this paper, the following can be stated:—

In the manufacture of steel balls the balls are forged heat treated, rough ground, emery ground and polished. As the result of 200 crushing tests on 1-in. balls it was found that the rough ground balls, although slightly larger in size, were 25 per cent. weaker than the polished balls.

Upon etching polished balls for 20 minutes in boiling hydrochloric acid, 25 per cent. solution, their crushing strength decreased 32 per cent. Upon etching round ground balls and polished balls in similar acid solutions, the same length of time, the crushing strength of the two came down to the same value, indicating that the reduction of crushing strength is not due to the effects of the acid, but rather due to the removal of the amorphous cement from the surface.

Although the amorphous cement theory might lead one to expect a quantitative difference in crushing strength between polished balls and balls which had their polish removed or else tested before they were polished, the author was sceptical before his tests, and expected the difference to be hardly noticeable. The difference of 30 per cent. indeed, seems phenomenal. It may yet be due to other causes which have not been detected. However, it should be borne in mind that although the amount of amorphous cement produced upon the surface of the steel balls by polishing is very little indeed, it is most advantageously placed to increase the crushing strength of steel balls.

The tests on steel balls were made in an especially designed machine, three balls being tested in line.

Commercial Aspects of Cold-Working Mild Steel.—One of the most desirable properties in steel is a high elastic limit coupled with a fair degree of ductility. Such high elastic limit is usually obtained by alloying steel or by heat treatment, or by a combination of both. However, any process tending to increase the elastic limit nearly always tends to decrease the ductility. In case of nickel steel, which gives a combination of high ductility and high elastic limit, the process of manufacture is expensive.

Possibly the most conspicuous feature of cold-worked mild steel is its high elastic limit coupled with its relatively high degree of ductility. Perhaps a few remarks should here be made about the best measure of ductility. Three different tests for ductility are ordinarily used—the bend test, the test to determine the percentage of elongation, and the test to determine the percentage reduction of area of the fractured specimens. The bend test is not satisfactory, because two specimens may be bent through an angle of 180 deg. and close completely upon themselves and yet be ductile in very different degrees. Furthermore, a bend test is of no use except for very brittle steels, as a $\frac{3}{4}$-in. round steels specimen 0·55 per cent. carbon, which behaves as a hard steel, may be bent to close upon itself, without developing cracks. The percentage of elongation test gives valuable information regarding ductility, but furnishes a poor standard, because on the one hand the results vary for different gauge lengths, and on the other hand the results are affected by the location of the point of fracture, viz., whether the fracture occurs on one of the gauge points, between gauge points or outside of the gauge points.

The percentage reduction of area after fracture can be measured regardless of size of specimen, and gives appreciable values when the percentage of elongation is often too small to be noticed.

The test for percentage of elongation naturally gives relatively small values for cold-stretched specimens, as most of the potential yielding is used up in the cold-stretching processes. Expressed in terms of percentage of reduction of area, cold-worked steel of an elastic limit of 70,000 lb. per square inch may have a reduction of area as high as 65 per cent. As regards the bend test, cold-worked steel of an elastic limit of 70,000 lb. per square inch may be bent double to close completely upon itself, without manifesting any tendency to crack, even in 1-in. square specimens. The decrease of ductility is very noticeable in commercial cold-drawing of shafting and wires; but in this case the cold-working is excessive, and, therefore it does not follow that with a more moderate degree of cold-working an elastic limit of 70,000 lb. per square inch, associated with a high degree of ductility cannot be obtained.

Steel has been cold-worked commercially with the object of improving its elastic properties, as in the case of hoisting cables and cables for suspension bridges. More often, however, cold-working is primarily resorted to for other purposes. Square reinforcing bars for reinforced concrete beams are cold-twisted for the supposed improvement in their bond properties. Wires and shafting are essentially cold-drawn because of the finished product it furnishes, true to size throughout.

Some tests on 50 reinforced concrete beams, made by the author in connection with this problem, varying in size from 4 in. by 6 in. by (4 ft. 6 in.) to 6 in. by 12 in. by (8 ft.), have shown that when cold-stretched steel is substituted for ordinary mild steel, the strength of a reinforced concrete beam is increased 80 per cent.

In tests on similarly reinforced concrete beams, alternately reinforced with square bars of mild steel and with cold-twisted square bars, the beams reinforced with cold-twisted bars showed an increase of strength of 35 per cent. over the beams similarly reinforced with plain bars, the same percentage of steel being used in both cases. If a high elastic limit is desired without the true finish associated with cold-drawing, cold-stretching may possibly be resorted to, which can unquestionably be accomplished with a great saving in cost of operation over the cold-drawing process. The pickling of the steel and the maintenance of the dies are totally unnecessary for cold-stretching steel.

Cold-drawing gives a beautifully true product with a somewhat increased elastic limit in torsion, as is manifested by curves K 63, Fig. 6, and curve 143(v), Fig. 9. However, if a high elastic limit in shear is desired, as for instance in case of shafts, much better results can be obtained by cold-twisting than by cold-drawing, as shown by curves K 64, Fig. 6, and curve 183(v), Fig. 9. This is true particularly when shafts are used to transmit torque in but one direction. If used to transmit torque in both directions cold-twisting and tempering still give superior results as indicated by curve 147(v), Fig. 9, but in that case the advantage is not so striking. However, it appears that a considerable percentage of modern shafts are designed to transmit torque in one direction only, and because of critical speed considerations the tendency often has been to use as light and flexible shafts as possible. If a light shaft is desired, therefore, as in the case of turbine or aeroplane shafts, may it not be possible to make use of the large increase in torsional elastic limit by cold-twisting, as is illustrated by curves K 64, Fig. 6, and curve 183(v), Fig. 9? When the perfection of the elastic properties, rather than the general increase of the yield-point, is of special importance it has been shown to be essential that cold-worked steel be tempered at temperatures not much less than that of boiling water.

One manufacturer of helical wire springs related that he was facing bankruptcy because of the large percentage of failures of his springs, until someone suggested to heat the springs in an oven. After heating the springs, which were manufactured of cold-drawn wire stock, they were able to pass the most severe tests for elasticity. Curves 143(v) and 144(v), Fig. 9, which are substantiated by several other tests, clearly show how such tempering perfects the elasticity in torsion of drawn wires. Lastly, steel balls have been carefully studied with reference to chemical composition and heat treatment. It appears that cold-grinding affects the ultimate strength of steel balls as much as either of the two above-mentioned factors.

Analysis of the Cold-Drawing Process.—The question is asked, "What are the effects of cold-drawing on steel?" It appears that, as far as the elastic properties of the specimen are concerned, the effects of cold-drawing are the same as those due to cold-stretching, and are thus illustrated by the several curves shown in this paper.

In experiments on copper bars, specimens obtained from identically the same stock were tested, hot-rolled, cold-stretched, and commercially cold-drawn. The last two tests gave very similar stress-strain curves.

As regards steel it was not possible to obtain the cold drawing of pre-tested hot-rolled stock. Therefore, tests were made on cold-drawn steel, the same steel annealed, then this annealed steel cold-stretched and subsequently tested in tension. Again, the stress-strain curves obtained for the commercially cold-drawn steel and the same steel cold-stretched were essentially the same. Nevertheless, painstaking metallurgical research has been directed towards the effects of cold-drawing on steel, and it has been found, for example, that the surface of a cold-drawn specimen exhibits a greater hardness than the centre, suggesting some essential difference between stretching a bar and cold-drawing a bar through a die.

The following interpretation of the process of cold-drawing is offered, which, considered in the light of what was said earlier in this paper about the effects of cold-working being a function of the cold-working strains and independent of the cold-working stresses involved, points out that the effects of cold-drawing on the elastic properties of steel are essentially the same as those of cold-stretching. It is well known that straining any material in one direction will produce a corresponding strain in a direction at right angles. Poisson's ratio purports to give the relation between the two strains at right angles to one another.

Bridgman has shown, in discussing the results of his extremely valuable experiments in the Jefferson Laboratory at Harvard University,* how a steel bar may be ruptured in the direction of its axis, by means of hydrostatic pressures acting at right angles to its axis only.

In cold-drawing, a bar is forcibly pulled through a die, as indicated by Fig. 1, page 99. The stress in the bar being defined as the load divided by the area, viz., $\frac{P}{A}$, will be somewhat larger at section B–B than at section C–C, because while the load P is essentially the same at both places, the area A_b is slightly smaller at section B–B than its corresponding area A_c at section C–C. We have seen, however, as is most forcibly illustrated by Bridgman, that the elastic limit will be exceeded when a critical strain value is passed regardless of the co-existing stress value.

Although the stress conditions at section C–C may be less severe, the strain conditions at section C–C are the most severe in the bar, because a relatively high stress $\frac{P}{A_c}$, is accompanied by very high compressive stresses acting normal to the axis of the bar. It has been pointed out how, when a specimen of mild steel is tested in tension and wedge grips are used, the elastic limit is passed, first in the ends of the specimen between the wedge grips, and from there progresses throughout the length of the bar.

In cold-drawing a very similar condition exists. The bar is strained beyond its elastic limit in the portion that is momentarily within the die. Its crystal grains are elongated very similarly to the way they would elongate under pure tension, the bar locally contracts and soon passes on beyond the outside of the die. There the side pressure is removed and the tensile stress $\frac{P}{A}$, without the aid of the normal pressure provided by the walls of the die, proves insufficient to strain the metal any further.

Thus cold-drawing becomes a continuous process. The die is so designed, determined entirely by the practice giving the best results, that the stress in the bar outside of the die is insufficient to permit of plastic flow of metal, while within the die, when the strain resulting from the direct pull is augmented by strains resulting from compression normal to the axis of the bar, plastic flow takes place.*

The Effects of Cold-Working upon Elastic Properties of Steel are Permanent.—The doubling or even tripling of tensile or torsional elastic properties of steel, if enticing to the man commercially interested in steel, inevitably leads him to inquire into the permanency of these effects. Curves on Fig. 12, stress-strain curves of cold-drawn steel which was aged at least six months and probably many months more, give some idea as to the permanency of the effects of cold-working upon steel. They manifest a perfect and high elastic range. Incidentally, they show how the elastic limit of steel is inevitably reduced to its original value upon heating it above the critical temperature and allowing it to cool in air. Possibly the most emphatic argument for the permanency of the beneficial effects of cold-working steel is found in the continued use of cold-worked steel during generations. It is stated that the Brooklyn Bridge, constructed in 1872, made almost throughout of cold-drawn wires, is permitted to be stressed at present at least to double the stresses for which it was designed, based upon the reports of various technical commissions. Cold-rolled shafting has been used for a great many years, and helical springs are preferably made of cold-drawn wire. Never, in such cases, has a loss of elastic properties been noticed with time. Although the merits of the square twisted reinforcing bar is a matter under dispute, it is never even intimated that its elastic properties may be deleteriously affected with time.

In conclusion, the author desires to express his appreciation of the advice and encouragement received from Professor W. C. Hoad and Professor Edward D. Campbell, of the University of Michigan, in carrying out his investigations, as well as his indebtedness to Mr. L. S. Cope, metallurgist of the Hoover Steel Ball Company, of Ann Arbor, Michigan, for the preparation of micrographs Nos. 1, 2 and 3, and for his liberal supplies of steel balls for the ball tests.

* "Breaking Tests under Hydrostatic Pressure and Conditions of Rupture," *Philosophical Magazine*, July, 1912.

* For a very interesting and authoritative paper on cold-drawing and its effects, see J. F. Tinsley, *Iron Age*, 1914, page 1,320.

THE RÖROS RAILWAY.—This railway, which is close to Drontheim, has suffered to an unprecedented degree from the spring flood, the damage done being the most extensive which has ever happened to a Norwegian railway. Over large distances the flood rose so suddenly that the railway and the surrounding country were flooded almost instantly. At Gulfos the large bridge was carried away, and in many places along the line the rails hang suspended in the air, the entire substruction having been carried away by the flood, as have also telephone and telegraph poles and several farms. At present it is impossible to estimate the extent of the damage.

IMPORT INTO FRANCE OF MACHINE PARTS OF BRITISH MANUFACTURE.—With reference to the issue by the French Customs Office in London of licences for the importation into France of parts of textile machines and of sewing machines, when such parts are of United Kingdom manufacture, the French Customs Office in London notify that the French Ministry of Commerce have decided that import licences shall now be granted by that Office for detached parts of all machinery of those classes the importation of which into France from this country may be licensed in London, provided, of course, that the detached parts for which a licence is sought have been manufactured in the United Kingdom.

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The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

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Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

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AGRICULTURAL APPLIANCES.

115,398. Alldays and Onions Pneumatic Engineering Company, Limited, N. L. Hilton and C. E. Simms, Birmingham. Motor Tractors. (2 *Figs.*) May 5, 1917.—In constructing the improved motor tractor constituting this invention, the frame of the vehicle is made of two longitudinal parallel bars or members *a*, preferably of a channel shape in cross-section, the said longitudinal bars being connected together by transverse crossing bars *b*, two of which project from the longitudinal bars or members at opposite sides of the frame, the projecting parts constituting brackets for supporting the ends of the rear springs *i* of the vehicle. The transverse or crossing bars or members of the frame are preferably of the same cross-section as the longitudinal bars. The axle-boxes for the axle of the

Fig. 2

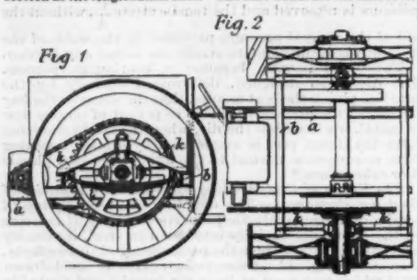


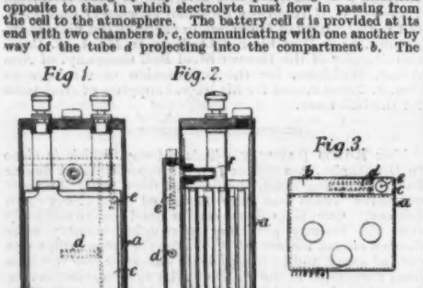
Fig 1

rear wheels are preferably attached to the upper side of the rear springs *i*, and screw mechanism or equivalent mechanism is provided for putting the springs out of action when a spring support for the rear of the tractor is not desired. When screw mechanism is employed, the screws may project from the upper sides of the axle-boxes and be passed through holes in bridge-like girders *k*, the ends of which rest on and are secured to the rear transverse bars *b* of the frame, the adjusting screw nuts on the said screws bearing on the upper sides of the bridge-like girders. In order to lock the springs out of action, a suitable distance-piece is inserted between the upper faces of the axle-boxes and the under side of the aforesaid bridge-like girders, and the adjusting screw nuts tightened up. (*Accepted May* 15, 1918.)

ELECTRICAL APPARATUS.

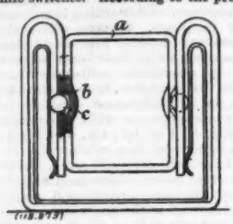
115,374. H. Dean and The Chloride Electrical Storage Company, Limited, Clifton Junction, near Manchester. Accumulators. (3 *Figs.*) October 30, 1917.—The invention comprises the combination with the battery cell, of a plurality of compartments in communication with one another, one compartment having an atmospheric connection through a vent tube and another having communication with the battery cell by a tube projecting into the cell at a point above the level of the electrolyte both when the cell is in the upright and in an inverted position, the communication between the compartments themselves being by way of a tube projecting in a direction opposite to that in which electrolyte must flow in passing from the cell to the atmosphere. The battery cell *a* is provided at its end with two chambers *b*, *c*, communicating with one another by way of the tube *d* projecting into the compartment *b*. The

Fig 1. *Fig. 2.* *Fig.3.*



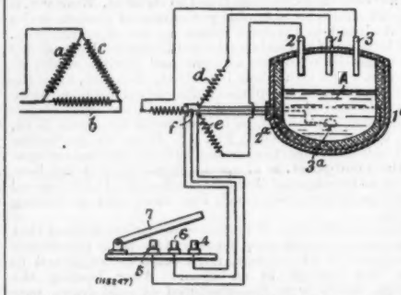
compartment *c* has an atmospheric connection by the tube *e*, while the compartment *b* is in free communication with the cell by way of the tube *f*. The latter is positioned above the level of the electrolyte in the cell both when the latter is in its upright and an inverted position, and the length of the tube is such as to prevent the flow of electrolyte therethrough when the cell is turned on the side containing said tube. Electrolyte therefore gains access to the compartment *b* with difficulty, but any electrolyte which may pass into said chamber due to splashing can readily return to the cell when the latter is turned on the side opposite to that in which the tube is situated. The tubes *d* and *e* likewise serve to prevent the passage of electrolyte therethrough in a direction away from the cell, the tube *d* acting as does the tube *f* to allow of a ready reverse flow. (*Accepted May* 15, 1918.)

115,373. P. G. Middleton, and C. J. Baker, Westminster. Switches and Fusible Cut-outs. (5 *Figs.*) October 23, 1917.—This invention relates to those switch devices in which a projection which may be a spring-actuated ball is formed in or mounted on one of the switch contact members and acts as a temporary locking means when the switch is in the closed position, by engaging in a recess in the other contact member. The purpose of the present invention is the application of temporary locking means in the form of a spring-actuated ball to U-form spring clips designed for use with fusible cut-outs, links and switches in which the clip is adapted to receive a blade, as for example in knife switches. According to the present invention,



the blades of the fuse bridge, the switch blade, the link or other movable blade member *a* have one or more pits, recesses or holes *b* formed on their side faces to engage with a projection *c* in a suitable position on the fixed U-form spring clip or contact. Instead of this the converse may be employed, viz., a projection on the movable member may engage in a recess in the fixed member. The projection *c* may be a spring-pressed steel or brass ball or may be merely a raised "pip." (*Accepted May* 15, 1918.)

115,247. The British Electric Transformer Company, Limited, and F. E. Berry, Hayes. Electric Furnaces. (2 *Figs.*) January 31, 1917.—This invention has reference to electric furnaces of the three-phase type having upper electrodes arranged above the furnace charge and lower electrodes in electrical connection with the charge and wherein the secondary windings of the associated transformer are so arranged that each phase is brought out to separate terminals, one of which is connected to an upper electrode and the other to a lower electrode. The drawing shows a three-phase transformer having its primary windings *a*, *b* and *c* mesh-connected and its secondary windings arranged to form the required three separate windings *d*, *e* and *f*. The corresponding ends of the secondary windings *d*, *e* and *f* are connected to electrodes 1, 2 and 3, respectively, at the top of the furnace, and the opposite ends of such windings are con-

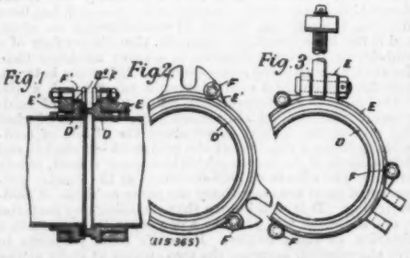


nected to the lower laterally-arranged terminals 1*a*, 2*a*, and 3*a* which are so arranged that they are located at parts of the furnace wall between the top and bottom of the furnace and much nearer to the bottom than to the top thereof, the said electrodes being in electrical connection with the furnace charge A below the surface thereof and above the bottom of the furnace hearth, either directly, or as is more usual and as shown, through the furnace lining which is conducting when heated. In order that the direction of the current through the charge A, and therefore the distribution of the heating action of the current thereon, may be varied, the terminals 1*a*, 2*a* and 3*a* in the furnace lining can be temporarily short circuited by a suitable switch. The three terminals of the secondary windings *d*, *e*, *f*, which are connected to the lateral electrodes 1*a*, 2*a* and 3*a*, respectively, are connected to stationary switch contacts 4, 5 and 6, which are connected together by a movable switch contact 7. (*Accepted May* 15, 1918.)

HYDRAULIC MACHINERY.

115,365. Mechans, Limited, and J. Thompson, Scotstoun, Glasgow. Flange Couplings. (7 *Figs.*) October 6, 1917.—Tubes have been provided with flange couplings, in which the flanged ends of tubes to be coupled are each provided with a collar, at the back of its flange, which is free to be turned and moved endwise thereon, one set of collars being provided to carry the bolts of the couplings, another set being formed to receive the outer ends of the bolts, so that, with two tubes and their parts in position for coupling, the two collars and thereby the flanged ends of the two tubes may be drawn together by the

Fig.1 *Fig.2* *Fig.3.*



bolts. According to this invention, provision is made for preventing or restricting the degree of freedom which the collars shall have to move endwise on the tubes, and, if desired, to turn about the axis thereof. For this purpose, a locking pin is provided fitted to project from the face of the collar having a head which is arranged to extend in front of a part of the flange of the tube and, if desired, project into a recess formed in the flange, the clearance at the face determining the degree of endwise freedom of the collar, and the clearance in the sides of the recess determining the extent to which the collar is free to turn. D, D1 designate flanges fixed respectively to the ends of two tubes, D being the flange behind which a bolt carrying collar E is provided, and D1 the flange behind which a collar E1 is provided having radial slots into which the outer ends of the bolts are adapted to be turned or removed. Each of the collars E, E1 is provided with a pin having a cylindrical head F, from which a cylindrical body F1 extends terminating in a screwed cylindrical end of smaller diameter than the body F1, which is fitted in position as shown and secured by a nut. On tightening the nut, the shoulder at the outer end of the body F1 is drawn against the face of the collar and the head F is thus maintained at the desired distance from the face of the collar E or E1. This distance practically corresponds to the thickness of a rim D2 which is provided about the periphery of the flange D or D1 by forming a circular recess in the front face of the flange, into which recess a portion of the head F projects. With this construction, the collar is only restricted against moving endwise on the flange of its tube. (*Accepted May* 15, 1918.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

115,390. A. B. Symons, London. Lathes. (3 *Figs.*) December 21, 1917.—This invention relates to tool-holders for lathes. According to the present invention, a tool-holder for a lathe is hinged to the carrier therefor for the purpose of allowing the tool to be temporarily removed from its cutting position and returned thereto without sliding the holder along the bed of the machine, so that the work may be examined closely or gauged. On the bed of the lathe A moves the saddle B operated by the lead screw C through the nut D. On the saddle B is arranged the cross-slide E by which the tool is moved across the face of the work. The cross-slide carries a hinged support F (see Fig. 3) having two extensions F1 in which is secured a pin H. The pin H is supported and rotates in a bearing J on the cross-slide E. The support F has two extensions G on the under side adapted to engage one with each of the side faces of the cross-slide E. The side faces and the inner faces of the extensions G are very carefully and accurately finished so that the hinged support fits exactly over the cross-slide. The support F carries a housing L, which is adapted to move longitudinally therein and forms a supplementary means of moving the tool. The housing L carries the cylindrical supplementary holder for the tool M, and the said supplementary holder has collars M1 to prevent endwise movement. The supplementary holder M carries a worm wheel O with which engages a worm P carried

Fig.1

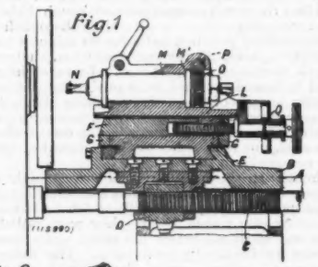


Fig.3.

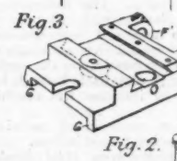
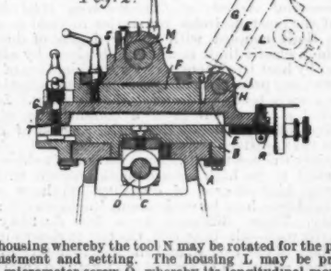


Fig. 2.



in the housing whereby the tool N may be rotated for the purpose of adjustment and setting. The housing L may be provided with a micrometer screw Q, whereby its longitudinal movement may be accurately determined, and similarly the cross-slide may be provided at one end with a micrometer screw R adapted to form a stop against the saddle B of the lathe, whereby its movement in one direction may be similarly determined. The amount of free movement in the other direction may be controlled by an adjustable stop not shown. The hinged support is secured to the cross-slide, when the tool is in the cutting position, by the bolt T. In operation, when it is desired to examine or gauge the work, the bolt T is loosened and the tool-holder is swung out of the cutting position into the position shown in dotted lines in Fig. 2. When the work has been examined or gauged, the tool-holder is swung back to the cutting position and the inner surfaces of the extensions G of the hinged support F come into contact with the side faces of the cross-slide and its under face comes into intimate contact with the upper surface of the cross slide, thus ensuring that the tool is returned accurately to its cutting position. When setting the tool, a straightedge is placed on the surface plate S, so as to overhang it, and the tool-holder is rotated by the worm P and worm wheel O so that the cutting edge of the tool comes just against the straight edge when it is known that the edge of the tool is at the exact axial centre of the lathe. (*Accepted May* 15, 1918.)

TRADING WITH THE ENEMY ACT.—The Controller of the Foreign Trade Department has issued a new list (No. 59) of additions to the statutory list of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained at a trifling cost from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.